OFFICE OF MINES AND MINERALS

PRACTICAL MINING MANUAL

ILLINOIS

DEPARTMENT OF NATURAL RESOURCES

ILLINOIS MINING LAWS

PRACTICAL COAL MINING
COURSE LESSON
ILLINOIS MINING LAWS

(Answers stated in simplified terms)

1. Q. What are the duties of a mine manager as prescribed by “The Coal Mining Act”?

A. He shall see that the mine examiner properly performs his duties as follows:

(The duties of the mine examiner; Section 6.04-6.11)

When performing his duties, he shall carry an approved gas detector in good working order, a sounding rod, an anemometer, a watch, a measure, pencil, paper, and chalk. Within 4 hours before the beginning of the shift, he shall examine all active working places, testing with an approved gas detector for firedamp, and for oxygen deficiency; he shall also test the roof, ribs and faces of active working areas, travel ways, roadways, and the approaches to abandoned workings for any unsafe condition. He shall use the anemometer to measure the amount of air passing through the last cross-cut of each pair of entries or in the last room of each division in the long-wall sections, and he shall measure the air at all other places where he deems necessary, to determine that the air is traveling in its right course. He shall examine the seals, doors, stoppings, brattices, and overcast to determine if they are in good condition. And as evidence of his examinations of working places, seals, doors, etc… he shall inscribe in chalk in some suitable place his initials and the date. If and when he discovers dangerous conditions of any kind, he shall place danger signs at all entrances to such places. If and when he finds places “behind in rock dusting” or places that are not sufficiently roof-bolted or other-wise properly timbered, he shall include these findings in his daily examiner’s record. Upon completion of his examination of the mine or of the sections of the mine assigned to him to examine, he shall make a daily record in ink or indelible pencil of his findings. If any dangerous conditions were found, he shall state the nature of the conditions in his report.

This report must be completed and signed by the examiner and checked by the mine manager before the men are permitted to enter the mine.

For all mines classified as “Gassy”. The mine shall be examined within 4 hours before the beginning of all shifts on which any work is done underground, whether coal producing or maintenance, except, on idle shifts and the only work to be done is in the shaft or around the immediate shaft bottom, then only the areas surrounding the bottom has to be examined.

For mines classified as “Non-gassy”, only one examination, 4 hours prior to the beginning of the first coal producing shift is required. At these mines, and on idle shifts, the examiner is required to examine only the section or sections where the men will work. For idle nights, the section or sections where work is to be done shall be examined only if it was not examined for the day shift.

The mine manager shall examine the examiner’s report and if dangers are reported, he shall instruct his bosses and or other workman as to the dangers reported and give appropriate instructions about correcting these dangers.

He shall see that his face bosses and other competent men make on-shift examinations at the faces and other active working places for any dangerous conditions at least once daily and as often as is needed.

He shall visit every active working place at least once every two weeks.

He shall require his face bosses to be in constant attendance of their sections and to visit each working place on his section at least once daily.

He shall provide a checking system to account for each man when he is in or out of the mine.

He shall provide timbers, props, roof-bolts, etc. for each place as needed.

He shall see that cross-cuts are made as required by law, also that doors, stoppings, brattices, and curtains are erected where needed.

He shall take a daily barometer reading and make record of same; if the barometer indicated changes that may create dangerous gassy conditions he shall notify his face bosses, examiners, and others who he deems should be on the look-out for such dangers.

He shall keep watch over the mine ventilating system and the air courses. If the mine fan should fail, he shall have the electricity cut-off in the mine and notify his face bosses and have the men withdrawn from the face regions. In the mines classified as "gassy", if the ventilation is restored within a reasonable time, the faces and other places where gas may accumulate shall be examined by competent men and if found safe, the power can be turned back on and work resumed. If it is found to be unsafe, the men must be removed from the mine until the mine is restored to a safe condition and reexamined.

He shall measure the mine intake and return and the air on each split at least weekly.

He shall examine or have examined the main escape ways and the escapement shaft at least once weekly. When unsafe conditions are found, a record of this shall be made and he shall see that these conditions are corrected immediately.

He shall have the safety catches, ropes and cages examined and tested each day before the men are lowered into the mine at the beginning of the day shift.

At shift mines and where men use cages, he must have cagers stationed at the top and bottom landings before the men are lowered into or hoisted from the mine.

He must see that adequate lighting is provided at top and bottom landings.

He or his assistants shall be on duty before the men are lowered into the mine and remain at the mine until they are hoisted out at the end of the shift.

He is responsible for the proper handling and storage of explosives used in the mine.

He shall make the necessary rules and instruct the men in the proper use and storage of explosives.

When coal is broken down on shift with compressed air, he shall see that the faces are properly examined before the faces are loaded out.

He shall see that roadways, belt lines and other places in the mine are kept free of excessive accumulations of loose coal and dust, and these places are properly rock dusted.

He shall see that the miners are instructed as to the requirements of the mining laws and require their compliance of these laws.

When his work requires help in fulfilling these duties, he may designate assistants who will carry out his duties as he deems necessary in the proper management of the mine.

2. Q. What does the Illinois Coal Mining Act require shall be done regarding excessive coal dust in a mine? Explain fully.

A. Coal dust and other combustible materials shall not be permitted to accumulate in dangerous quantities in active underground workings of a mine.

Where underground mining operations raise an excessive amount of dust into the air, water or water with a wetting agent added to it or other effective methods shall be used to allay the dust at its source. All underground mines, except those mines or areas of mines in which dust is too wet or too high in incombustible content to propagate an explosion, shall be rock-ducted to within 40 feet of all faces. In mines where rock-dusting is required, rock-dusting shall be started at the bottom and rock-dusting shall be maintained as the mine is developed; haulage ways, parallel entries, rooms and cross-cuts shall be rock-dusted. Where rock-dust is applied, it shall be distributed upon the roof, floor, and sides of all open places and maintained in such quantity that the incombustible content of the combined coal dust, rock-dust and other dust will not be less than 65%. Where methane is present in ay ventilating current, the 65% of incombustible content of such dust shall be increased 1% for each 0.1% of methane.

3. Q. What is the law regarding refuge places along haulage roads?

A. Refuge places shall be provided not more than 60 feet apart along haulage entries. Room necks and cross-cuts may be used as refuge places. Refuge places shall be kept clear of refuse and other obstructions.

4. Q. How shall trips be marked when pulled or pushed by a motor?

A. A trip-light or reflecting signal shall be used on the rear of trips being pulled and on the front of trips pushed by a motor, and also on the front of trips lowered into slopes.

5. Q. **What is the law regarding refuge places where men get on and off man trips?**

   A. Where man trips are operated there shall be on one side of the man trips, where men get on and off, a refuge place at least 3 feet from the rail and free from all obstructions for the full distance of the man trips.

6. Q. **What is the law with regards to stoppings in coal mines in the state?**

   A. In cross-cuts connecting main and cross entry inlet and outlet air courses the permanent stoppings shall be erected of incombustible materials, and shall be erected within 600 feet of the face of mine and cross entries at all times. Temporary stoppings of wood or other equally effective material shall be maintained, as nearly air tight as possible, between the last permanent stopping and the cross-cut nearest the face in the main and cross entries. In room and stub entries the stoppings shall be built of wood or other equally effective material. All stoppings shall be kept in good condition, so as to keep air up to the working faces.

7. Q. **What does the Illinois Mining Law require every workman to first do when he goes into a place to work? Discuss fully.**

   A. Every miner shall sound and thoroughly examine the roof, ribs, and face of his working place before commencing work, and if he finds loose rock or other dangerous conditions, he shall not work in such dangerous place except to make such dangerous conditions safe.

8. Q. **After what period of time must the men be removed from a mine if the fan stops?**

   A. When the ventilating fan at any mine fails or stops, immediate action shall be taken to cut off the electric power and withdraw workmen from the face regions of the mine. In non-gassy mines if the ventilation is restored within a reasonable time the power may be turned on and work resumed without the necessity of re-examination. In gassy mines if the ventilation is restored within a reasonable time, the face regions and other places where methane is likely to accumulate shall be re-examined by competent personnel, and if such region and places are found to be free from explosive gas the power may be restored and work resumed.

9. Q. **What is the minimum quantity of air that must enter a mine as prescribed by the state mining law?**

   A. In non-gassy mines not less than 150 cubic feet per minute for each workman. In mines classified as gassy, not less than 200 cubic feet per minute per man. In these cases the quantity of air must be measured at the foot of the downcast and of the upcast.

10. Q. **What is the minimum quantity of air that must be passing through the last open cross-cut between the intake and return of any pair or set of entries?**

    A. Not less than 9,000 cubic feet per minute, however, if in the opinion of the State Mine Inspector, the quantity of air in any case is inadequate, he can give a written order increasing the amounts required.

11. Q. **What is the minimum percentage of oxygen allowable in the air ventilating the working places and section?**

    A. 19.5%

12. Q. **What is the maximum percentage of methane allowable in active working places?**

    A. 1%

13. Q. **What is the maximum percentage of carbon dioxide allowable in active working places?**

    A. 0.5%. No quantities of noxious or poisonous gases are allowed in the air currents of any mine in the state.

14. Q. What are the laws of Illinois in reference to persons seeking certificates as mine examiners?

A. He shall be a citizen of the United States; he shall be at least 21 years of age; he shall have temperate habits and a good reputation; at least 4 years of practical mining experience, except, if he holds a degree in mining engineering from an accredited school, then he is required to have only 2 years of underground experience as prescribed by the Illinois Mining Board as to his ability to perform the duties of a mine examiner. And completed courses in mine First Aid and methods of mine rescue.

15. Q. What are the laws of Illinois in reference to persons seeking certificates as mine managers?

A. He shall be a citizen of the United States; be at least 24 years of age; have completed courses in first aid and mine rescue; have temperate habits and have a good reputation; have at least 4 years of underground mining experience and pass the state examination to his ability in the management of mines.

16. Q. Under what conditions may the certificate of a mine manager, hoisting engineer, or mine examiner be cancelled or revoked?

A. Any certificate issued by the Department may be cancelled or revoked by said Department upon notice and hearing; if it is established in the judgment of said Department that the holder thereof had obtained said certificate by fraud or misrepresentation of his experience or has become unworthy to hold said certificate.

17. Q. What are the rights of the person against whom such charges or complaints that the holder of the certificate of mine manager, hoisting engineer or examiner should be cancelled or revoked?

A. Any person against whom charges or complaints are made thereunder shall have the right to appear before the Department and defend himself against said charges, and he shall have 15 days notice in writing of such charges previous to such hearing; provided, that the Department in its discretion, may suspend the certificate of any person charged as aforesaid, pending such hearing, but said hearing shall not be unreasonably deferred.

18. Q. List the code of signals prescribed by the Coal Mining Act for use at coal mines in this State for signaling between the top, the bottom and the hoisting engineer.

A. From the bottom to the top; one ring or whistle shall signify to hoist coal or empty cage, and also to stop either when in motion. Two rings or whistles shall signify to lower cage. Three rings or whistles shall signify that men are coming up or going down; when return signal is received from the engineer the men shall get onto the cage and the proper signal to hoist or to lower shall be given. Four rings or whistles shall signify to hoist slowly, implying danger. Five rings or whistles shall signify accident in the mine and a call for a stretcher. Six rings or whistles shall signify hold cage perfectly still until signaled otherwise. From top to bottom; one ring or whistle shall signify, all ready, get on cage. Two rings or whistles shall signify, send away empty cage. The operator of any mine may, without the consent of the State Mine Inspector, add to the code of signals.

19. Q. What does the Illinois mining law require a Mine Examiner to carry with him when making an examination of a mine?

A. An approved gas detector, anemometer, watch, measure, pencil, writing pad, sounding rod and chalk.

20. Q. What is the law regarding minimum number of workmen allowed on each split or division of mine air?

A. The main current of air shall be so split or subdivided as to give a separate current of reasonably pure air to every 100 men. The State Mine Inspector has the authority to order, in writing, separate currents for smaller groups of men, if in his judgment special conditions render it necessary.

LESSON A

Brief requirements, duties and Responsibilities of the Mine Examiner, Decimals and Fractions, Percentage

A. Mine Examiner

I. Brief Requirements.

He must:

A. Be a citizen of the United States, at least 21 years of age, with four years of practical mining experience, of good repute and temperate habits.

B. (Mining engineers who have graduated and hold degrees in mining engineering from and accredited school, college, or university, need have only two years of underground experience)

C. Complete a course in first aid and mine rescue.

D. Pass an examination covering:

1. Experience in mines generating dangerous gases.
2. Nature and properties of fire damp (METHANE).
3. Safeguards against fires from any source in mines.

II. Brief duties and responsibilities

A. He shall examine, as required in the Mining Act for gassy and non gassy mines, the working areas and active roadways of the mine; in particular, methane and oxygen deficiency; seals and doors; roof, face, and rib conditions; abandoned areas and accessible falls, and the ventilation in each split.

B. Face bosses must be mine managers or mine examiners.

Decimals and Fractions

Fractions are the way we show quantities of less than one. One-half, one-quarter, two-thirds, are all fractions. They are written using two numbers, one above the other, separated by a line. For example, one-half is written ½.

The bottom line indicates how many parts the unit of whatever you have is divided into; the top line shows how many parts you actually have. ½ foot says that if you divide a foot into 2 parts; you have one of them.

2/5 inch says that if you break an inch into five equal parts, you have two of them.

What does ¾ pound mean?

If you break a pound into 4 parts, you are concerned with 3 of the parts.

You can multiply or divide (but **NOT** add or subtract) the top (dividend) and bottom (divisor) of a fraction by the same number and not change the value what the fraction is equal to of the fraction.

$$2/3 \text{ equals } \frac{2 \times 2}{3 \times 2} = 4/6 \text{ equals } \frac{2 \times 3}{3 \times 3} = 6/9$$

$$2/3 \text{ does not equal } \frac{2 + 3}{3 + 3} = 5/6$$

$$\text{Does } \textbf{not} \text{ equal } \frac{2 + 5}{3 + 5} = 7/8$$

Fractions can be changed into usual tens-place numbers. These **decimals** can be found by dividing the top number by the bottom number. For example, ¾ equal .75; the numbers are after the **decimal point** to show that the number is less than one.

```
     .75
4  3.000
    28
     20
     20
      0
```

In the same way, 4/5 equals .8

```
    .8000
5  4.0000
```

Zeros after the last number in a decimal do not have any effect. Decimals can be added and subtracted like ordinary numbers.

.767		
1.495	1.985	2.418
.685	- .41	- 1.677
2.947	1.575	.741

Decimals can also be multiplied like ordinary numbers, but you must be careful to mark off in the answer the total number of places after the decimal point, that are in the numbers being multiplied. Examine the following examples closely.

27.6	1.5	2.24
4	6	8.7
110.4	9.0	1568
(one place)	(one place)	1792
		19.488
		(three places)

4.67	3.89
.3	.07
1.401	.2723
(three places)	(four places)

When dividing into a decimal, you must be sure to place the decimal point correctly. Again, study the examples carefully.

```
     .14              .8
11  1.54         26  20.8
    11               20.8
     44                 0
     44
      0
```

When dividing by a decimal, multiply the division and dividend by 10 enough times so that you are dividing by a "whole" number that is, with no numbers after the decimal point. Remember, since you are multiplying both divisor and dividend by the same amount, you aren't changing its value.

```
                ______        ______        __7.5_
1.14    8.550  =  11.4   85.50  =   114   855.0
                                           798
                                            570
                                            570
                                              0

      ______    ______     __600_
.03   18  =  .3  180  =  3  1800
```

Practice Problems

1. Find the decimal equivalents of these fractions:

   1/8= 3/7= 4/5=

   2/3= 11/16= 5/12=

   A. .125; .429; .8; .667; .6875; .4167

2. Add (subtract) these columns of numbers (hint: change to decimal form before adding):

1/3	4/7	3/5		
1/4	1/9	1/3	1/2	3/4
1/5	1/8	1/2	- 1/3	- 1/8

   A. .783; .807; 1.433; .167; .625

3. Add (subtract) these columns of numbers:

.495	.189		
.6	.17	.675	1.67
.87	4.2	-.284	-.865

   A. 1.965; 4.559; .391; .805

4. Multiply the following numbers:

3.59	14.87	.485	.17
2	3.2	16	2.48

   A. 7.18; 47.584; 7.760; .4216

5. Divide the following numbers:

```
     _____       _____       _____
17   89.25   24   9.6    18  137.52
```

   A. 5.25; .4; 7.64

6. Divide the following numbers:

$6.5\overline{)650}$ $.14\overline{)11.2}$ $.002\overline{)9876}$

A. 100; 80; 4,938,000

A percentage is a fraction with the bottom number (denominator) equal to 100. In other words, we take the unit we are concerned with (foot, pound) and divide it into 100 parts. The number of percent shows how many of the 100 parts we have.

An example of a percentage is 75%. The symbol % stands for a denominator of 100. Therefore, 75% equals 75/100, 33% equals 33/100, and so on.

A decimal can be changed to a percentage very easily by multiplying it by 100 and adding a % sign. This is because adding a % is the same as multiplying the denominator by 100. What we are doing here, then, is multiplying both the numerator (top number – given decimal) and the denominator by the same number (100). Again this will not change the value of the number. To change a fraction to a decimal, first convert it to decimal form.

3/4 = .75 = 75%	5/4 = 1.25 = 125%
1/10 = .10 = 10%	1/7 = .143 = 14.3%

LESSON B

Air, Perimeter, Ventilating Pressure, Horsepower, Formulas, Problems, Answers

B. The Mathematics of Ventilation

Area: The area of an airway is found by multiplying its width by its height.

$$A = WH$$

If a passage is 12 feet wide and 6 feet high, its area is 12 x 6 = 72 square feet.
If the passage is wider at the bottom than at the top, add the two widths and divided by two to find the average width. Multiply this by the height to get the area.

$$A = \frac{(W1 + W2)}{(2)} (H)$$

If the top width is 8 feet, the bottom width is 16 feet and the height is 6 feet, the area is:

$$\frac{16 + 8}{2} (6) = (12)(6) = 72 \text{ square feet}$$

The area of a circle is equal to Pi (π, pronounced "Pie") times the square of the radius (the radius multiplied by itself):

$$A = \pi R^2 \qquad \text{is a constant equal to } 3.1416$$

If a circle has a radius of 3 feet (a diameter of 6 feet), its area is (3.1416) (3) (3) = 28.2744.
The velocity of air is the speed at which it passes through the mine. It is determined with an anemometer, and is shown by V.
The quantity or volume of air passing through a passageway is equal to the area of the passage time the velocity of the air.

$$Q = AV$$

If the area of a passage is 72 square feet, and the velocity is measured at 500 feet per minute, the quantity of air passing through the mine is (72) (500) = 36,000 cubic feet per minute.
Where dimensions are given in feet and inches, change them to feet and fractions of a foot before multiplying. For example, 6 feet 3 inches is 6.25 feet or 6 ¼ feet.

Problems

1. A passage is 5 feet high and 9 feet wide. What is the area?
   A: A = 5 (9) = 45 square feet.
2. What is the area of a crosscut 16 feet wide by 6 feet high?
   A: A = (16) (6) = 96 square feet.
3. Find the area of an airway 5 feet 6 inches high and 14 feet wide.
   A: A = (5.5) (14) = 77 square feet.

4. A passage is 10 feet wide at the bottom, 6 feet wide at the top, and 7 feet high. What is the area?

   A: $A = \frac{10 + 6}{2} = 8 \times 7 = 56$ square feet.

5. An airway is 12 feet wide at the bottom, 9 feet 6 inches wide at the top, and 6 feet high. What is the area?

   A: $A = \frac{12 + 9.5}{2}(6) = (10.75)(6) = 64.50$ square feet.

6. What ist he area of a pipe 5 feet across? DIAMETER = 5 feet, RADIUS = 2.5 feet.

   A: (3.1416) x (2.5) x (2.5) = 19.635 square feet.

7. In a passage measuring 80 square feet, the velocity of air is measured at 250 feet per minute. How much air is passing through the passage?

   A: Q = 80 (250) = 20,000 cubic feet per minute.

8. In an airway 7 feet from top to bottom, and 16 feet across, air velocity is 280 feet per minute. What is the quantity of air passing through?

   A: A = 7 (16) = 112 square feet.

   Q = (112) x (280) = 31,360 cubic feet per minute.

Since the quantity of air is equal to the area times the velocity, the velocity can be found by dividing the quantity by the area.

$$V = \frac{Q}{A}$$

Also, the area can be found by dividing the quantity by the velocity.

$$A = \frac{Q}{V}$$

9. 32,000 cubic feet per minute of air passes through an area of 80 square feet. What is the velocity of air?

   A: $V = \frac{32{,}000}{80} = 400$ feet per minute.

10. 36,000 cubic feet per minute of air is moving through an air course at 400 feet per minute. What is the area of the course?

    A: $A = \frac{36{,}000}{400} = 90$ square feet.

1. To find the percentage (%) of methane when the cubic feet of methane and the total quantity are known, divide the cubic feet of methane by the quantity.
2. To find the cubic feet of methane, when the percentage (%) and cubic feet of methane are given, multiply the quantity by the percentage.
3. To find the total quantity of air when the percentage (%) and the cubic feet of methane are given, divide the cubic feet of methane by the percentage (%).
4. To find the total quantity of air needed to reduce the percent of methane to a given percent, multiply the original percent by the original quantity of air and divide b the desired or reduced percent of methane.

Problems

1. Find the percent of methane when the cubic feet of methane is 1050 cfm. And the cubic feet of air is 300,000 cubic feet minute.

   A: $\% = \frac{1050}{300{,}000} = .0035$ or 35%

2. Find the cubic feet of methane if the percent f methane is .4% and the quantity of air is 300,000.

   A: 300,000 x .004 = 1,200 cfm

3. Find the quantity of air when the percent of methane is .3% and the quantity of methane is 1,500 cfr. Methane.

   A: $\frac{1,500}{.003}$ = 500,000

4. Find the total quantity of air needed to reduce the percent of methane from 1.5% to .5% if the quantity of air is 200.000 fpm.

   A: 1.5% of 200,000 = 200,000 x .015 = 3,000

   CHy - % CHy = TRAL

   $\frac{3,000}{.005}$ = 600,000 cubic feet of air

Perimeter: The perimeter of an airway is the sum of its sides. It is shown by the letter O.

$$O = W + H + W + H = 2W + 2H$$

A passage is 6 feet high and 14 feet across. The perimeter is 6 + 14 + 6 + 14 = 40 feet

The circumference of a circle is equal to Pi (π) times the diameter, or 2 times the radius.

$$C = \pi D = 2 \pi R$$

If a shaftway is 12 feet across, the circumference is (3.1416) (12) = 37.6992 feet

The rubbing surface of an airway is the total surface area of the passage. It is obtained b multiplying the perimeter by the length of the passage.
The rubbing surface of a circular airway is equal to the circumference times the length.

$$S = LO$$

If the airway is 12 feet wide and 6 feet high, and 1,500 feet long, its perimeter equals 12 + 6 + 12 + 6 = 36 feet; its rubbing surface equals 54,000 square feet.
A circular shaft has a radius of 8 feet and a length of 700 feet. The rubbing surface is (2) (3.1416) (8) (700) = 39,168 square feet.
The rubbing surface divided by the area of the airway gives the rubbing surface per square foot.
The rubbing surface of a passage is 240,000 square feet, and the passage is 16 feet wide and 5 feet high. There is :

$$\frac{240,000}{80} = 3,000 \text{ square feet}$$

of rubbing surface per square foot of passage.

The resistance to air travel caused by the roughness of the ribs, roof and floor and other irregularities such as corners is allowed for by fractions called the coefficient of friction (K). K is a constant, whose value depends on the roughness of the surface. It is often taken to be .00000002.
The pressure caused by a fan blowing air through a mine can be found by multiplying the coefficient of friction times the rubbing surface, and this product times the velocity squared (the velocity times itself), and dividing this final product by the area. The answer will be the ventilating pressure in pounds per square foot.

$$P = \frac{KLOV^2}{A} = \frac{KSV^2}{A}$$

A passage is 15,000 feet long, 6 feet high, and 12 feet wide. Air velocity is measured at 500 feet per minute. The area is 6 x 12 = 72 square feet. The perimeter is 6 + 12 + 6 + 12 = 36 feet. The rubbing surface is (15,000) (36) = 540,000 square feet. The pressure is:

$$\frac{(.00000002)\ (540,000) \times (500 \times 500}{72} = 37.5 \text{ pounds per square feet.}$$

Ventilating pressure is the force which must be used against air to push it through the mine, providing ventilation to the mine. This air not only gives working miners fresh air to breathe, but also carries away dangerous gases which could otherwise build up.

The ventilating pressure is measured by a water gauge. For each inch shown on the water gauge reading (WG), there is 5.2 pounds per square foot of pressure. P = 5.2 WG. If the water gauge reads 4 inches, the pressure is 20.8 pounds per square foot.

The water gauge reading can be found by dividing the pressure by 5.2.

$$WG = \frac{P}{5.2}$$

The pressure is 28.6 pounds per square foot. The water gauge should read:

$$\frac{28.6}{5.2} = 5.5 \text{ inches}$$

Problems

1. What is the perimeter of a crosscut that is 5 feet 6 inches high and 8 feet wide?
   A: P = 5.5 + 8 + 5.5 + 8 = 27 feet
2. Find the perimeter of a shaft that measures 10 feet by 15 feet.
   A: P = 10 + 15 + 10 +15 = 50 feet
3. What is the circumference of a circular shaft 14 feet across? Circumference or distance around a circular shaft is obtained by multiplying diameter or distance across x (times).
   A: Diameter = 14 feet
   C = (14) (3.1416) = 43.9824 feet
4. Determine the circumference of a circle that has a radius of 5 feet.
   A: C = (2) (3.1416) (5) = 31.416 feet
5. A passageway is 17 feet wide by 6 feet high by 250 feet long. What is the rubbing surface?
   A: S = (250) (46) = 11,500 square feet
6. A circular airway has a height of 8 feet and a length of 500 feet. Find the rubbing surface.
   A: C = (8) (3.1416) = 25.1328 feet
   S = (25.1328) (500) = 12,566.40 square feet
7. An air course is 15 feet wide by 5 feet high by 600 feet long. What is the rubbing surface? Also find the rubbing surface per square foot of passage.
   A: O= 15 + 5 + 15 + 5 =40 feet
   S = (40 (600) = 24,000 square feet
   A = (15) (5) = 75 square feet
   $\frac{S}{A} = \frac{24,000}{75} = 320$
8. A passageway has a rubbing surface of 240,000 square feet and an area of 75 square feet. An anemometer shows the air velocity as 500 feet per minute. Find the ventilating pressure. K = .00000002
   A: $P = \frac{(.00000002)\ (240,000)\ (250,000)}{75} = 16$ pounds per square foot
9. What pressure is required to ventilate a section 5 feet high by 16 feet wide by 3,000 feet long, where the velocity is 450 feet per minute?
   A: $P = \frac{(.00000002)\ (3,000)\ (42)\ (202,500)}{80} = 6.37875$ 0 = 42 feet
10. The water gauge reads 4.7 inches. Find the pressure.
    A: P = (5.2) (4.7) = 24.44 pounds per square foot
11. The water gauge reads 2.6 inches. What is the pressure?
    A: P = (5.2) (2.6) = 13.52 pounds per square foot

12. The pressure is 11.96 inches. What should the water gauge read?

    A: $WG = \frac{11.96}{5.2} = 2.3$ inches

Horsepower

Horsepower is a measure of work. Actually, it is a measure of the power needed to do work – for example, to ventilate a mine, one horsepower is the amount of work required to raise 33,000 pounds 1 foot in 1 minute.
The horsepower used to ventilate a mine is found by multiplying the quantity of air being pushed through the mine per minute by the ventilating pressure per square foot, and then dividing by 33,000.

$$HP = \frac{QP}{33{,}000} \qquad P = \frac{33{,}000\ XHP}{Q} \qquad Q = \frac{33{,}000\ XHP}{P}$$

The horsepower is required to ventilate a mine when 75,000 cubic feet of air is required per minute with a water gauge reading of 2.5 inches?

$$\frac{(66{,}000)\ (3)\ (5.2)}{33{,}000} = 31.2 \text{ horsepower}$$

Problems

1. What horsepower is required to ventilate a mine when 75,000 cubic feet of air is required per minute with a water gauge reading of 2.5 inches?

    A: $HP = \frac{(75{,}000)\ 2.5)\ (5.2)}{33{,}000} = 29.5$ horsepower

2. If a fan produces 60,000 cubic feet of air per minute with a water gauge reading of 2.2 inches, what is the horsepower of the fan?

    A: $HP = \frac{(60{,}000)\ (2.2)\ (5.2)}{33{,}000} =$ horsepower

3. If 150,000 cubic feet of air per minute is produced with a water gauge of 3.3 inches, what is the horsepower producing this quantity of air?

    A: $HP = \frac{(150{,}000)\ (3.3)\ (5.2)}{33{,}000} = 78$ horsepower

4. A fan using 25 horsepower is pushing 50,000 cubic feet per minute of air through a mine. What is the ventilating pressure, and what will the water gauge read?

    A: $P = \frac{33{,}000\ (25)}{50{,}000} = 16.5$ pounds per square feet

    $WG = \frac{16.5}{5.2} = 3.17$ inches

5. The quantity of air entering a mine is 100,000 cubic feet per minute. If the effective power on the ventilation is 40 horsepower, what would be the height of the water gauge?

    A: $\frac{33{,}000\ (40)}{100{,}000} = 13.2$ pounds per square foot

    $WG = \frac{13.2}{5.2} = 2.54$ inches

6. If a fan is 75% efficient, what would be the rating (the ideal horsepower the motor could produce) of a motor used on a fan required to pass 132,000 cubic feet per minute of air through a mine against a ventilating pressure of 10.4 pounds per square foot?

   A: 132,000 x 10.4 = 41.6 horsepower
   HP = 41.6 horsepower utilized
   RATING = 55.5 horsepower
   (41.6 = 75% of 55.5)

7. With a fan 8 feet in diameter, making 250 revolutions per minute and passing 62,000 cubic feet per minute, when the water gauge stands at 1 inch. What would be the rating of the fan motor if the fan is 80% efficient? 9.77 – 80%

   A: $HP = \frac{(62,000)\ (5.2)}{33,000} = 9.77$ horsepower used
   RATING 12.2 horsepower (The size of the fan and its speed does not matter)

Review List of mathematical Formulas

$A = WH$

$A = \frac{W1 + W2}{2}\ H$

$A = \pi R^2$

$Q = AV$

$O = W + H + W + H = {}^2W + {}^2H$

$C = 2 \quad R = \pi D$

$S = LO$

$P = \frac{KLOV^2}{A} \quad \frac{KSV^2}{A}$

$P = 5.2\ WG$

$HP = \frac{Qp}{33,000}$ or $HP = \frac{U}{33,000}$

$U = Qp$

A = Area
W = Width
H = Height
W1 = Bottom width
W2 = Top width
π = Constant = 3.1416
R = Radius
Q = Quantity (volume) of air
V = Velocity of air
O = Perimeter
C = Circumference of circle
D = Diameter
S = Rubbing Surface
L = Length of passage
P = Ventilating Pressure
p = Small p x area is total pressure
K = Constant (coefficient of friction) = .00000002 (usually)
WG = Water gauge readings (inches)
HP = Horsepower
U = Work

A Few More Words

These formulas are very important in making sure that a mine is properly ventilated. There must be enough fresh air for the men to breathe, and to carry dangerous gases away from the working areas. When used properly, the mathematics will let you, the examiner, know that an area is safe to work in, and is acceptable under the law.

It is a good idea to re-measure periodically the areas where air is checked. With time, because of roof falls and the like, the area can become larger. Because Q = AV, the same quantity of air as before will cause a smaller anemometer reading – leading to a false alarm if the examiner did not know that the area had in fact increased. The formulas should be used with up-to-date measurements of the passage.

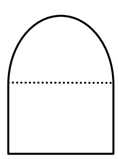
For example, if the examiner were using an old measurement of an air passage that was 6 feet high and 15 feet wide, and the actual measurement were 7 feet high and 16 feet wide, and the anemometer read 200 feet per minute, we would have the following:

“READING”
A = 90 square feet
V = 200 feet per minute
Q = 18,000 cubic feet per minute
“TRUE”
A = 112 square feet
V = 200 feet per minute
Q = 22,400 cubic feet per minute

If 20,000 cubic feet per minute of air were required, you can see the trouble the misleading answer would cause!

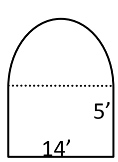
Many Mines no longer use only rectangular passages. For example, there are often arched passages. The area and perimeter of many of these passages can be gotten by dividing them into “simpler” shapes.

Let’s look at an arched passage where the arch is made up of a semi-circle.



We can see that the passage is made of a rectangle plus a semi-circle. The perimeter is the sum of the bottom and the two sides of the rectangle and the edge of the semi-circle. The area is equal to the area of the rectangle plus the area of the semi-circle.

For example, take the passageway below.

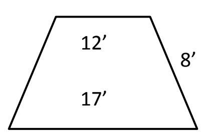


The arch is a semi-circle whose radius is 7 (14 x 1/2) feet. The circumference of the semi-circle is (1/2) (2 R) or R. C = 7 (3.1416) = 22 feet. The area of the semi-circle is (1/2) (R^2). A = (1/2) (49) = 77 square feet. The perimeter of the passage is 5 + 14 + 5 + 22 = 46 feet. The area of the passage is 70 + 77 = 147 square feet.

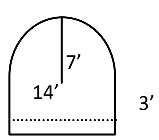
Remember that not all arches are semi-circular, and that there may be other passage shapes. If there is any doubt as to the area or perimeter, check with the mine engineer!

Problems for Practice and Review

1. We have an airway that is 7 feet high and 10 feet wide, and the anemometer shows that 500 feet is the velocity per minute. What is the quantity of air passing per minute?
2. If the velocity of air current is 75 feet per minute in an airway 6 ½ feet by 19 ½ feet, what is the quantity of air passing per minute?
3. The large hand of the anemometer goes around 4 ½ times in an airway 6 feet high and 12 feet wide. Allowing 3% for friction, what would be the velocity of the air current and what quantity would there be passing in the airway?
4. An airway 7 feet by 6 feet in section is passing 28,000 cubic feet of air per minute. What quantity will an airway 5 feet by 5 feet pass if the velocity is the same in each airway?
5. If 15,400 cubic feet of air is passing through an entry which is 5 feet 6 inches high and 14 feet wide, what is the velocity of this air current?
6. The anemometer shows 150 feet per minute in an airway that measures 10 feet 6 inches at the top, 12 feet 6 inches at the bottom, and is 6 feet high. Find the quantity of air passing per minute.
7. Find the velocity per minute of air traveling (a) 10,000 feet in 14 minutes; (b) 375 feet in 30 seconds (c) 2,000 feet in 2 minutes 20 seconds.
8. An anemometer is held in five different positions for one minute each. Find the quantity of air passing an airway 7 feet by 12 feet, allowing 5% for friction of the instrument, if the readings are 112, 125, 120, 114, and 116.
9. The velocity in an airway 6 feet by 12 feet is 500 feet per minute. What will be the velocity where the airway is constricted to an area 5 feet by 12 feet?
10. The hand of an anemometer turns 3.75 times each minute. The airway is 9 feet high, 4 feet 6 inches wide on top and 6 feet 6 inches wide at the bottom. Find the velocity of the air current, allowing 4% for resistance of the anemometer, and the volume of air passing per minute.
11. The hand of an anemometer turns 3.25 times per minute in an airway 6 feet 3 inches high and 8 feet 6 inches wide. What is the quantity of air passing in this airway, allowing 3% for resistance of the anemometer?



12. A trapezoidal ( ) airway is 12 feet wide at the top and 17 feet wide at the bottom. The slant height is 8 feet, and the length of the passage is 2,450 feet. Find the perimeter and rubbing surface.



13. What is the perimeter of an arched airway ( ) if the arch is formed by a half-circle and the bottom is formed by a rectangle which is 14 feet wide and 3 feet high? The distance from the floor to the top of the arch is 10 feet.
14. What is the distance around a circular shaft which is 14 feet in diameter?
15. An airway is 7 feet high and 8 feet wide and the rubbing surface per square foot of section is 2,684 feet. What is the length of the airway?
16. What is the rubbing surface per square foot of section, for an airway 7 feet high, 11 feet wide and 4,572 feet long?
17. If the rubbing surface of an air course is 72,000 square feet and its length 3,600 square feet, what is the perimeter?
18. The total rubbing surface of a 500 feet airway is 16,000 square feet. 80,000 cubic feet of air is passed each minute. The airway is square. What is the velocity of the air current?

19. What is the perimeter of an arched airway, with a semi-circular arch 10 feet in diameter, the arch starting 5 feet above the floor? Its area? If the airway is a slope 300 yards long, what is the rubbing area?
20. What is the rubbing surface of a circular drift opening 14 feet in diameter and 18,800 feet long?
21. A water gauge gives a reading of 4 ½ inches. How much pressure is there against a 3 feet by 6 feet 6 inch door at the point?
22. If there is a 2.5 inch water gauge at a 6 feet by 9 feet door between the intake and return entries of a section, how much pressure is there against this door?
23. What pressure will be required to pass 30,000 cubic feet of air per minute through an airway 6 feet high by 10 feet wide by 5,000 feet long? K = .00000002
24. An airway 6 ½ feet by 12 ½ feet by 4,000 feet long has 40,625 cubic feet of air passing per minute. Find the pressure required to ventilate this section of the mine. K = .00000002
25. If the average height is 4 feet and the average width is 9 feet and there are 130,000 square feet of rubbing surface in a certain air course, what will be the pressure when the velocity is 310 feet per minute?
26. What horsepower is required to ventilate a mine when 66,000 cubic feet of air is required with a water gauge reding of 3.2 inches?
27. The water gauge reads 3.3 inches. To force 45,000 cubic feet per minute of air through the mine, what must the rating on a 75% efficient fan be?
28. An airway is 16 feet wide and 6 feet high and 5,000 feet long. An anemometer gives a velocity of 400 feet per minute. K = .00000002. A 30 horsepower fan will send how much air through the fan?

Problem Answers

1. 35,000 cubic feet
2. 9,018.75 cubic feet
3. 464 feet is the velocity; 33,408 cubic feet is the quantity
4. 667 feet is the velocity; 16,675 cubic feet is the approximate quantity
5. 200 feet per minute
6. 10,350 cubic feet
7. (a) 714 feet; (b) 750 feet; (c) 857 feet
8. 123 approximate, is the velocity; 10;332 cubic feet is the quantity
9. 600 feet per minute
10. The velocity is 390 feet per minute; the quantity is 19,305 cubic feet
11. 17,796.9 cubic feet (approximately 17,800 cubic feet)
12. The perimeter is 45 feet; the rubbing surface is 110,250 square feet
13. 20 feet (bottom) plus 22 feet (arch) equals 42 feet
14. Approximately 44 feet
15. 5010 feet. The area of the airway is 56 square feet. The rubbing surface equals 56 times 2,684 or 150,304. The length equals 150.304 divided by 30 (the perimeter), or 5010 feet
16. 168,192 is the rubbing surface; 2184.3 the rubbing surface per square foot of section
17. 20 feet
18. O = 32 feet; A = 64 square feet; V = 1250 feet per minute
19. O = 35.7 feet; A = 89.27 square feet; S = 32,130 square feet
20. 826,869.12 square feet
21. P = (5.2) (4.5) = 23.4 pounds per square feet. The door is 19.5 square feet; total pressure against the door is 456.3 pounds
22. P = (5.2) (2.5) = 13 pounds per square feet. The door is 54 square feet total pressure against the door is 702 pounds
23. 13.3 pounds per square feet
24. The velocity is 500 feet per minute; the ventilating pressure is roughly 9.4 pounds per square feet.
25. 6.94 pounds per square feet
26. 33.28 hp
27. USED = 23.4 hp; RATING = 31.2 hp
28. P = 7.3 pounds per square feet
    Q = 135,616 cubic feet per minute

LESSON C

Air and Gases, Absolute Temperature, Relative Humidity

C. Introduction to Air and Gases

Air is a mixture of gases. The two main components, or ingredients, of air are nitrogen and oxygen, although there are other gases present in small amounts. To understand mine ventilation, therefore, it is useful to understand some of the properties of gases.

Matter can be divided into three different groups. **Solids** have a definite form and shape which can only be changed by force – coal, wood, and so on. **Liquids** will change shape to fit the containers they are in, but will not generally leave the containers unless an outside force (such as heat or pressure) is used. Water and milk are examples. **Gases** will take the shape of any closed containers in which they are placed, but will not stay in an open container, instead mixing with the surrounding atmosphere.

These different forms can be explained by chemistry. All matter is made up of many very small building blocks called **molecules**. Each of these molecules are units of the substance, but so small that they cannot be seen even with a microscope. Depending on how strongly the molecules are bound together, we have solids, liquids, or gases.

In solids the molecules are bound together firmly. It requires force to break them apart. In liquids the binding is weaker, and the molecules will move freely around each other, although they will still tend to remain attached to one another. Gases have almost no binding, and will therefore spread throughout a container, depending on the amount of gas, the temperature, and the pressure.

All gases expand when heated and contract when cooled. Thus, a gas at 80˚ F. will occupy a larger volume than a gas at 40˚ F. This is important in mining because of the presence of dangerous gases in abandoned workings. A rise in the temperature could cause these gases to expand into currently used areas, causing an unsafe condition.

All gases expand or contract under change of pressure. If pressure is applied to any gas, it will contract and occupy less space. If a gas is under pressure, a lessening of the pressure will cause the gas to expand and occupy a greater volume.

The quality of air varies inversely proportionally to the absolute pressure. The absolute pressure means the normal atmospheric pressure plus the ventilating pressure.

Atmospheric pressure is not constant, but changes over time. This is what a weatherman is talking about when he mentions “high pressure fronts” or “low pressure fronts.” He is referring to atmospheric pressure.

Atmospheric pressure also depends on the height (relative to sea level) of the point where it is being measured. This pressure is caused by the weight of the air above pushing down. Thus, the lower the elevation of measuring point, such as deeper in a mine, the greater the amount and weight of air pushing down on it, and the greater the atmospheric pressure.

Atmospheric pressure is measured by a barometer. Each inch on the barometer stands for .49 pounds per square inch. This is equal to 70.56 pounds per square feet since there are 144 square inches per square foot. A normal sea level reading is 30 inches, or 14.7 pounds per square inch, or 2,116.8 pounds per square foot. At locations above sea level, the normal reading is below 30 inches.

Relative Humidity

The atmosphere always contains an amount of water vapor – water in gas form. This is measured as **relative humidity**. This means that the amount of water vapor actually in the air is compared to the amount that **could** be in the air. For example, if the air is half-saturated with moisture, the relative humidity is 50%

If the air contains 2/3 the amount of water it could hold, the relative humidity is 67%.

The amount of moisture that a given volume of air will absorb depends on the temperature of the air. The warmer the air, the more moisture it can absorb. Air that is fully saturated at 40˚ F. will contain about tone half the weight of moisture that air that is fully saturated at 60% relative humidity, at a temperature of 70˚F., will carry twice the moisture (by volume) as air of the same humidity at 50˚ F.

As air warms up, it can absorb more moisture. As it cools down, it can absorb less moisture. Thus, with a given amount of moisture present, warming air will decrease the relative humidity, and cooling air will increase the relative humidity.

Thus is winter the intake air will dry out a mine as the air warms up to the mine temperature. In summer, the mine will become more humid as the intake air cools.

When the humidity is low, the danger of fire is increased. High humidity is extremely uncomfortable, and work becomes difficult and inefficient.

LESSON D

Oxygen, Nitrogen, Methane, Carbon Monoxide, Carbon Dioxide, Hydrogen Sulphide, Gas Chart

Gases

Atmospheric air, used to ventilate mines, consists of oxygen (O^2) – 20.93%, by volume; nitrogen (N^2) – 78.10%; carbon dioxide (CO2) - .03%; and other gases in small quantities – less than 1%. Mining operations release gases other than oxygen and nitrogen.

The specific gravity of a gas is its weight compared to that of the same volume of air. For example, if one cubic foot of a gas weighs twice as much as one cubic foot of air, its specific gravity is 2.9. One way of identifying a gas is by its specific gravity.

Oxygen, shown by the chemical symbol O^2, is essential for human life. It is tasteless, odorless, and colorless, and is detected with an O^2 detector.

There is a deficiency of oxygen where there is less than 19.5% oxygen in the air. Breathing becomes faster and deeper as the deficiency increases, and it is more difficult to work. Atmospheres with less than 16% oxygen are dangerous, and persons in them should carry protection.

Oxygen supports combustion, and will combine with other gases to form explosives or inflammable mixtures. It is found naturally in the atmosphere, and as a specific gravity of 1.105.

Nitrogen (N^2), specific gravity .967, makes up almost four-fifth of the natural atmosphere. It is tasteless, odorless, and colorless. Nitrogen is not combustible, nor will it support combustion. Therefore, it does not have an explosive threat. Excess nitrogen in the air leads to death by suffocation, as it replaces oxygen in the blood.

It is found naturally in the air, and is also a product of cool oxidation (oxygen in the air combining with coal). Thus, it is present in large quantities in the afterdamp of a mine fire; it remains when the oxygen is burned away.

Methane (CH^4), also known as **Marsh Gas**, is a colorless, odorless, and tasteless combustible gas, released during the mining operations from coal and adjoining strata. Because it comes from the coal, and because it is much lighter than air—Its specific gravity is 0.555—it is usually found along the roof to the rises, near working faces, in dead ends, and around falls.

Methane is not explosible itself; oxygen is needed to support combustion. While methane will burn (is combustible), it will not support combustion. Methane **will** combine with air to form an explosive mixture known as "fire damp". Firedamp is not methane—firedamp is methane plus air. There is great danger of explosion when the methane content is between 5% and 15%. Where there is less than 5% methane, the heat of combustion is dispersed quickly enough to prevent flames. Where there is more than 15% methane, there is not enough oxygen for rapid combustion. Coal dust in the air reduces the lower explosive limit. It is possible to have an explosion with less than 5% methane if coal dust is present in the air.

Methane will ignite at approximately 1100 to 1380 degrees Fahrenheit.

Although not poisonous, methane will replace oxygen in the blood and cause death by suffocation if breathed in high concentrations. It can be detected by a methane detector, and by chemical analysis.

Carbon Monoxide (CO), known as whitedamp, is a colorless tasteless, combustible and poisonous gas which results from incomplete combustion. This happens when there isn't enough oxygen for the burning to be completed. Carbon Monoxide is found after mine fires and explosions, for example and around internal combustion (such as gasoline and diesel) engines.

Carbon Monoxide is **extremely** poisonous—0.10% causes complete collapse. Carbon Monoxide combines with the blood and excludes oxygen. It has been shown that blood "prefers" carbon monoxide to oxygen by a factor of 300. This will lead to a shortage of oxygen in the body, and often rapid death. The effect of carbon monoxide is worsened because it is not easily thrown off. It builds up in the blood over time.

Carbon Monoxide is also explosive over a wide range—12.5% to 74%. It ignites at approximately 1100˚F. While its explosiveness must not be forgotten, the most dangerous feature of carbon monoxide is its poisonous character.

Carbon Monoxide may be detected by a CO detector or chemical analysis. Its specific gravity is .967.

Carbon Dioxide (CO^2), or blackdamp, results from **complete** combustion, and also from the breathing of men and animals. It is colorless and odorless, and is detected by a CO^2 detector or chemical analysis. The specific gravity is 1.529.

Carbon Dioxide is incombustible, it will not burn. Nor will it support combustion. Its danger is that it causes difficult breathing—5% causes breathing effort to increase 300%, for example, ½% will have a noticeable effect.

Hydrogen Sulphide (H2S), also known as "stinkdamp" because of its rotten egg odor, is an extremely poisonous gas even in small amounts. 0.07% will cause death in one hour, smaller doses will destroy olfactory (smelling) nerves.

The gas is combustible, and will ignite at 700 degrees F. It is also explosive over a wide range—4.3 to 46. Hydrogen sulphide is rarely found—occasionally in old pipe lines in poorly ventilated places. It is also the by-product of the burning of black powder—illegal in the mines of Illinois.

Hydrogen sulphide can be detected by a chemical analysis or by use of an H2S detector. Its specific gravity is 1.191.

The atmosphere following an explosion or mine fires is known as "afterdamp". It consists of carbon dioxide, carbon monoxide, decreased oxygen, nitrogen, hydrogen, and smoke. It can be extremely dangerous to breathe, so it is important to use proper breathing protection.

Problems

1. **What gas (gases) make up the following:**
   Marsh Gas
   Firedamp
   Whitedamp
   Stinkdamp
   Blackdamp
   Afterdamp
   A. Methane; methane plus air; carbon monoxide; hydrogen sulphide; carbon dioxide, carbon monoxide, decreased oxygen, nitrogen, hydrogen, and smoke.
2. **What is meant by the specific gravity of a gas?**
   A. The specific gravity of a gas is its weight compared to that of the same volume of air.
3. **What is the importance of oxygen?**
   A. Oxygen (O2) is necessary for human survival. It is the oxygen in the air we breathe that keeps the human body alive. Also, while oxygen itself does not burn, it supports combustion. Without oxygen, there could not be mine fires.
4. **What is meant by a deficiency of oxygen? What are the effects of an oxygen deficiency? Below what level of oxygen in the air is there said to be a deficiency?**
   A. Oxygen deficiency exists where there is not enough oxygen for men to normally carry on active work. Breathing becomes faster and deeper, and it is harder to work. A deficiency exists, according to the Mining Act, where there is less than 19.5% oxygen in the air.

5. **What is the importance of Nitrogen?**

A. Nitrogen is neither combustible, supporting of combustion, nor poisonous. However, generally the more nitrogen in the air, the less oxygen; therefore, excess nitrogen often means an oxygen deficiency.

6. **What is the importance of methane?**

A. Methane is combustible, and will mix with air to form "firedamp"; an extremely explosive mixture. When the methane content of air is between 5 and 15%, there is a great danger of explosion.

7. **What is the effect of oxygen on the dangers from methane?**

A. Oxygen is needed to support combustion of methane, and therefore causes "firedamp" to be explosive. The less oxygen present, the more methane required for a given explosive force.

8. **What is the effect of coal dust on the explosibility of methane?**

A. Coal dust too is explosive. Thus, the presence of coal dust increases the explosive potential, the possible explosive force, of a given mixture of "firedamp". In the same way, the presence of methane will increase the explosive potential of coal dust. The presence of coal dust will also lower the amount of methane that must be present for an explosion.

9. **What are the dangers of carbon monoxide?**

A. Not only is carbon monoxide combustible, but it is **extremely** poisonous. The blood prefers carbon monoxide to oxygen by a factor of 300, leading to death by a deficiency of oxygen. This effect is worsened because carbon monoxide is not easily thrown off.

10. **Where is carbon monoxide found?**

A. Carbon monoxide results from incomplete combustion—where there isn't enough oxygen for burning to be completed. It is found after mine fires and explosions, and near internal combustion engines.

11. **Where is carbon dioxide found?**

A. Carbon dioxide results from complete combustion, and also from the breathing of men and animals. Thus, small amounts are always found; larger amounts are found after mine fires and explosions. Because it is comparatively heavy, it would be found near the floor, in dip workings, and in poorly ventilated places.

12. **What is the danger of Carbon dioxide?**

A. There is no fire or explosive danger. However, it causes difficulty in breathing—if present in quantities greater than ½% of air, the effect will be noticeable.

13. **What is the danger of Hydrogen sulphide?**

A. Hydrogen sulphide is **extremely** poisonous—0.07% will cause death in one hour. Lesser amounts will destroy the sense of smell. Although the gas is also explosive over a wide range00this range is far into the fatal (death causing) dose.

14. **What is afterdamp?**

A. Afterdamp is the atmosphere following an explosion or mine fire. It consists of carbon dioxide, carbon monoxide, nitrogen, hydrogen, decreased oxygen and smoke. It can be extremely dangerous.

15. **How may the following be detected:**

Methane
Carbon Monoxide
Hydrogen Sulphide
Carbon Dioxide
Nitrogen
Oxygen

A. CH^4—Methane detector, chemical analysis.
CO—CO detector, chemical analysis.
H^2S—H2S detector, odor, chemical analysis
CO^2—CO^2 detector, chemical analysis.
N^2—N^2 detector, chemical analysis.
O^2—O^2 detector, chemical analysis.

GAS CHART

	METHANE	CARBON MONOXIDE	HYDROGEN SULPHIDE	CARBON DIOXIDE	NITROGEN	OXYGEN
Chemical Symbol	CH^4	CO	H^2S	CO^2	N	O^2
Specific Gravity	.55	.967	1.191	1.5291	.967	1.105
Incidence in the air (%)	*	*	*	.03	78.10	20.93
Is it combustible?	Yes	Yes	Yes	No	No	No
Does it support combustion?	No	No	No	No	No	Yes
Is it poisonous?	No	Yes	Yes	No	No	No
How is it detected?	Safety Lamp Methane Detector Chemical Analysis	CO Detector Chemical Analysis	H2S Detector Chemical Analysis Odor	Chemical Analysis Safety Lamp	Chemical Analysis Safety Lamp	Chemical Analysis Safety Lamp
Explosive range percentage in air	5 to 15%	12.5 to 73%	4.3 to 46%	None	None	None
Ignition temperature Fahrenheit	1100 to 1380 deg.	1100 deg.	700 deg.	None	None	None
Origin	Occluded in Coal and Clay Veins; Decomposition of Vegetable matter in water	Incomplete combustion; Mine Fires; Explosions and Blasting	Rarely found; Old pipe line in poorly ventilated places	Complete combustion; small quantity found naturally in air	Found naturally in air; Coal oxidation frees Nitrogen	Found naturally in air
What is its effect of life:	Causes death by suffocation if breathed in high concentrations; effect passes off in fresh air	.10% in air causes complete collapse; Excludes Oxygen from the blood	.07% causes death in one hour; very poisonous; destroys olfactory (sense of smell) nerves	Causes death by suffocation; Excludes oxygen from the blood; labored breathing	Causes death b suffocation; Excludes Oxygen from the blood	Necessary for life

*Less than 1%

LESSON E

Ventilation—Definitions; Contaminated Mine Atmosphere; Required Ventilation; Fans; Devices Controlling Ventilation—Overcast, Doors, Stoppings, Line Brattices, Check Curtains, Regulators; Problems

Ventilation

Introduction

The basic objective of mine ventilation is to provide an adequate supply of uncontaminated air to the working areas. To achieve this end it is sometimes necessary to course intake air through several miles of underground airways. Leakage is severe, but with planning—using existing techniques—adequate air volumes can be supplied to the last open crosscut out by the active fact.

Coursing the air available in the last open crosscut to the face and distributing the air in the immediate face area are two of the major ventilation problems facing the bituminous coal industry today. When the primary ventilation system is adequate poor face ventilation may result from one or a combination of these factors. Many of the methane ignitions in underground bituminous coal mines be attributed to poor face ventilation.

Volume of Air Delivered by the Line Brattice

The volume of air required to ventilate the active face in a gassy mine is determined by the rate of methane liberation from exposed face and ribs. To dilute these emissions and prevent dangerous accumulations, the face ventilating system must supply adequate volumes of air as near the liberating source as possible. For this reason an efficient system must develop a controlled air sweep across the face and rib with minimum secondary flow. Flow patterns in the face area are critical and fresh air penetration must extend from the terminus of the ventilating source to and across the active fact.

Definitions

1. **Anemometer-** Instrument for measuring air velocity.
2. **Bleeder entries-** Special air courses developed and maintained as part of the mine ventilation system and designed to continuously move air-methane mixtures emitted by the gob away from active workings and into mine return air courses.
3. **Brattice cloth-** Fire resistant fabric or plastic for directing air into face of heading.
4. **Check Curtain-** Sheet of brattice cloth hung across an airway to control passage of air current.
5. **Float dust-** Fine coal particles carried in suspension by air currents and eventually deposited in return entries.
6. **Gob area-** Part of mine from which coal has been extracted and resulting space more or less filled by fallen material.
7. **Intake-** Air passage by which ventilating current enters mine. In underground mining, a ventilating passage through which fresh air is conducted to working face.
8. **Main Fan-** Mechanical ventilator installed at surface; operated either exhausting or blowing to induce air flow through mine roadways and workings.
9. **Split of air-** Any division or branch of ventilating current.
10. **Stopping-** Airtight wall built across a mine passage to control air flow.
11. **Working face-** Any place in a coal mine where coal is extracted from its natural deposit during mining cycle.

Air Splitting

Splitting the air is necessary for safety as well as for minimal power cost. With each working section on a separate split, each crew is assured of fresh air supply; this is uncontaminated by dust and gas accumulated by passage through a previously ventilated section. Air splitting also sectionalizes portions of the mine, thus reducing the possibility that an explosion will propagate from one section to another section.

Regulating splits allow better control of the local atmospheres. In a coal producing section, if both development and a pillar line must be ventilated, mining should be planned in such a manner that the development is ventilated first and the pillar line last so that the return air current passes directly into the gob or enters the mine return air course.

Face Ventilization

The basic objective of mine ventilation is to provide an adequate supply of uncontaminated air to the working areas. The volume and velocity of the current of air shall be sufficient to dilute, render harmless, and carry away flammable, explosive, noxious, and harmful gases, dust, smoke, and explosive fumes. It is sometimes necessary to course intake air through several miles of underground airways. Leakage is severe if not controlled, but with the planning—using existing techniques—adequate air volumes can be supplied to the last open crosscut out by the active face.

Coursing the air from the last open crosscut to the face and **distributing** it in the face area are the two primary ventilation problems. Even though the primary ventilation system is adequate, poor face ventilation may result from poor planning and installation of face ventilation control devices. Many of the methane explosions in underground coal mines can be attributed to the inadequate face ventilation.

CONTAMINATED MINE ATMOSHPERE

Causes of Contamination of Mine Atmosphere

Normal operations of the mine contribute to contamination of the air after it enters the main fan.

1. Digging both manual and machine, disperses coal dust and releases gases into the air.
2. Blasting and digging change the forces in roof, rib, floor and face; and allow trapped gas pockets to escape in gusts into the mine air.

Additional hazards are created by unexpected occurrences in the mine.

1. An excess accumulation of gas in the mine may cause a fire or explosion with resulting products of combustion entering the mine atmosphere.
2. Changes in the contour of roof, floor, rib, or face may occur gradually or suddenly as in worked out or abandoned rooms resulting in the emission of trapped gases.
3. Pressure from the strata or aging of materials may cause seals of abandoned areas to collapse or develop leaks which permit high gas level areas to emit contaminants into the air.

Gassy Mines

If the State Mine Inspector finds methane by a legally recognized means in the amount of 0.25% or more, in an open workings of a mine when tested at a point not less than 12 inches from the roof, face, or rib, the mine shall be classified as gassy.

Other mines are classified as non-gassy.

Almost all Illinois mines are classified as gassy.

Main Intake Requirements

1. **Well rock dusted**
2. **Free of Debris**
3. **Roof adequately supported**
4. **Drainage system**
5. **Adequate capacity**
6. **Minimize leakage**

Ventilation

As we discovered in earlier pages, the air that miners breathe is of great concern. Too little oxygen, and the efficiency—in severe cases the lives—of the men are endangered. Too much of the dangerous gases, the same problem.

There are two basic principles of mine ventilation:

1. to provide enough pure air to the miners, assuring an adequate supply of oxygen;
2. to dilute, render (make) harmless, and carry away the dangerous gases resulting from mining operations.

An important part of the examiner's job is to make sure that these principles are put into practice, keeping in mind the health, safety, and efficiency of the miners.

Required Ventilation

The ventilating current to the underground working places must contain not less than 19.5% of oxygen, not more than 0.5% of CO_2, and no harmful quantities of other noxious or poisonous gases.

There must be no less than 9,000 cubic feet per minute of air reaching the last open crosscut in an pair or set of entries; except that in pillar sections it may be less if not less than 9,000 cubic feet of air is being delivered to the intake end of the pillar line. In robbing areas where the air currents cannot be obtained, the air shall have perceptible movement.

There must be at least 150 cubic feet of air per minute for each person employed, measured at the foot of the downcast and of the upcast. In a mine where explosive gas can be detected with an approved detector, there must be at least 200 cubic feet per minute for each person. The State Mine Inspector may require these quantities to be increased.

The main current of air shall be so split as to give a separate current of reasonably pure air to every 100 men at work. The State Mine Inspector may require separate currents for smaller groups of men if he finds it necessary.

If methane is detected in quantities greater than 1.0% in the return of a split of air, or at a working face when tested not less than 12 inches from the roof, face, or rib, changes in the ventilation shall be made at once to reduce the methane content to be no more than 1.0%.

If methane is detected in quantities 1.5% or greater in the return of a split of air, men shall be withdrawn from that section of the mine endangered and all power cut off from such portion of the mine until the amount of methane is less than 1.5%. Under certain conditions in virgin territories, this applies when the methane content reaches 2.0%. See Sec. 31.06 of the Mining Act.

Air enters the mine through the **intake** and leaves through the **return**. The current must be so directed that fresh air reaches all men and working areas, being split when necessary. The velocity must be great enough to carry off the dangerous gases released in mining; but low enough to be comfortable. The air flow must be reliable, and as efficient as possible. These are the concerns of efficient mine ventilation.

Circulation of air is a result of difference in pressure along the air path—air flows from areas of high pressure to areas of low pressure. Fans are used to create high pressure at the intake (intake fans) or low pressure at the return (Exhaust fans), causing air to flow from intake to return.

The intake ventilating current is directed to the points where it is needed by the use of **control devices** along airways. These include doors, stoppings, overcasts, brattices, curtains, and regulators. They keep the air on the desired paths, and prevent "short circuiting", air reaching the return before ventilating the working areas.

Fans

The fans should be located on the outside of the mine, in buildings of incombustible (non-burning) material. They should not be placed directly in mine openings, but rather off to one side, connected to the opening by means of air ducts. The opening should also be equipped with explosion doors. This will protect the fan in case of an underground explosion; the explosion doors relieve the pressure of an explosion before it reaches the fan.

The fans should be reversible, so that the air currents may be reversed—if this is advisable—in case of fire or explosion. They are to be run off a separate power circuit, independent of the mine circuit.

Ventilating fans are to be inspected daily.

Ventilating fans shall be operated continuously.

Where the fans stop, the workmen shall be removed immediately from the face regions of the mine, and the electric power shall be cut off. In a gassy mine, if the ventilation is restored within a reasonable time, the face regains and other places where methane is likely to accumulate shall be reexamined by competent personnel, and if the areas are found free of explosive gas the power may be restored and work resumed. If the ventilation is not restored within a reasonable time all underground employees shall be removed from the mine. In non-gassy mines, if the ventilation is restored within a reasonable time, the power may be turned on and work resumed without the necessity of reexamination.

A booster fan is one placed in the mine to handle the total volume of air of one or more splits. In other words, it boosts the air current delivery by the outside fans. By improper use they may recirculate the air, permitting accumulations of gas and causing a fire hazard. Also, they may not be within reach after an explosion or fire—making control of the situation much more difficult. Booster fans are permitted only with special permission of the State Mining Board, and they are rarely found.

Blower fans with tubing, used to direct the flow of air, are allowed only if certain precautions are taken—See section 21.24 of the Mining Act. When used, they must be kept in good working order and inspected at least twice during each working shift.

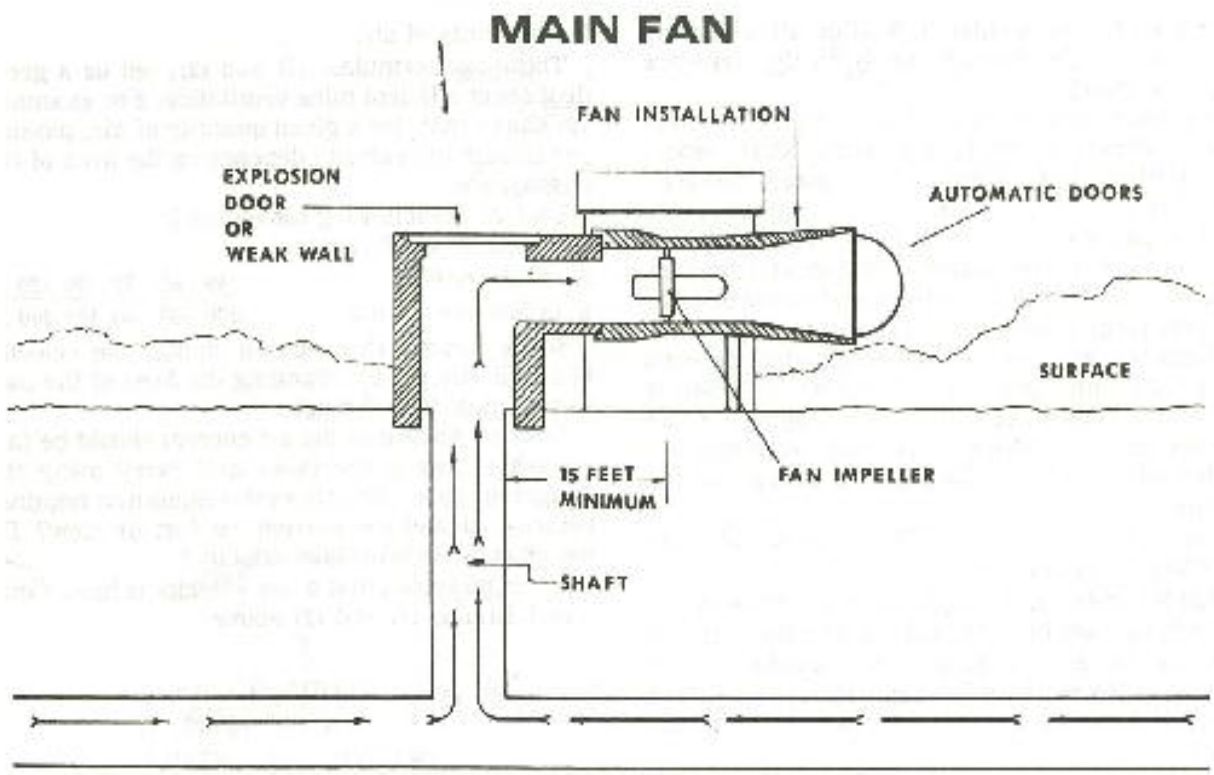
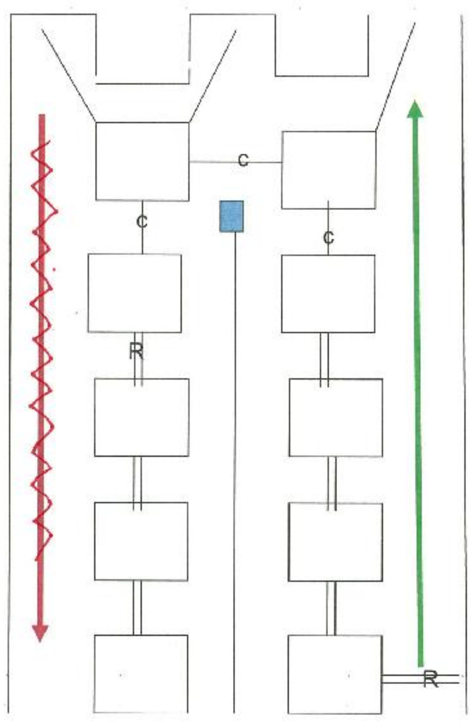
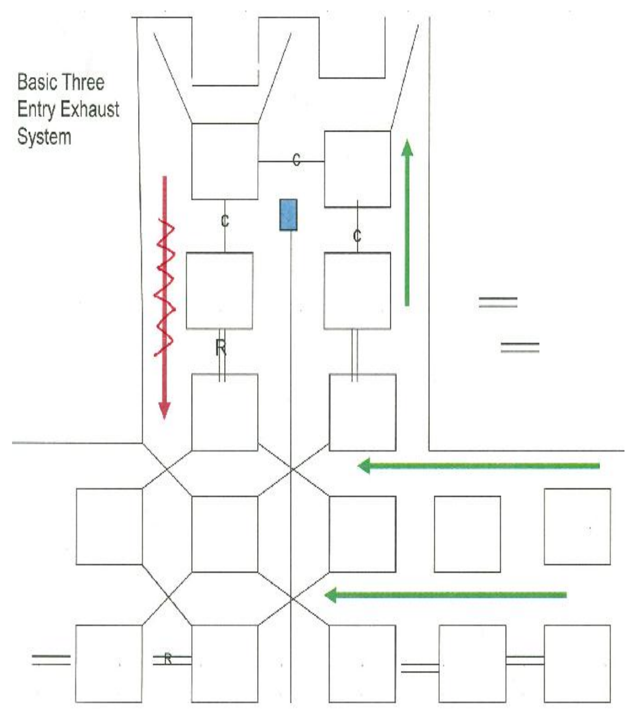


DIAGRAM OF MAIN FAN AT SHAFT



BASIC BLOWING SYSTEM



BASIC THREE ENTRY EXHAUST SYSTEM

Devices for Controlling Ventilation

Overcasts—An overcast is an enclosed airway that permits one air current to cross another. Overcasts should be airtight, and built of incombustible materials.

They allow an uninterrupted flow of air, and eliminate the need for doors, making haulage easier and removing the ventilation problems that doors cause.

Doors—Doors are used to deflect air currents and still allow passage of men and machinery. They are usually one or more piles of wood, with canvas or brattice cloth often nailed to the edges to reduce air leakage.

Doors have several great disadvantages, and should not be used except where there is no other choice. Air leakage can be quite severe, defeating the purpose of the door. With time, hinges may wear; doors may warp or e damaged, increasing the air loss. They interrupt haulage, and by carelessness may be left open, short-circuiting large amounts of air away from the face.

Doors should be made to close automatically—and under no circumstances should they be propped open, or otherwise prevented from closing. Persons who open doors are responsible for seeing that the doors are closed before leaving them.

Stoppings— Stoppings are partitions erected across openings so that air shall not pass through the openings. They differ from doors in that they cannot be moved, thus men and haulage cannot pass through.

One purpose of stoppings is to prevent short-circuiting of the ventilating current. In addition, they are used to seal off portions of the mine—such as worked out areas, burning areas, and the like. The sealing off of large abandoned areas means they need not be ventilated. Sealing off a burning area cuts off oxygen supply to the fire—one way of fighting it.

Stoppings may be made from a number of materials—concrete, brick, tile, rock, slate, wood, and brattice cloth. Wood and perishable material should be used only for temporary stoppings, since they permit great leakages of the ventilating current and are a fire hazard. Permanent stoppings should of durable (long lasting) and incombustible (non-burning) material. Gob must not be used.

Stoppings, especially those expected to be used for a long time (permanent), should be air-tight and substantially built. Leaky stoppings mean wasted air, and where abandoned workings are sealed off, a leakage of dangerous gases into the ventilating current.

Stoppings must be carefully checked for leakages and dangerous gases.

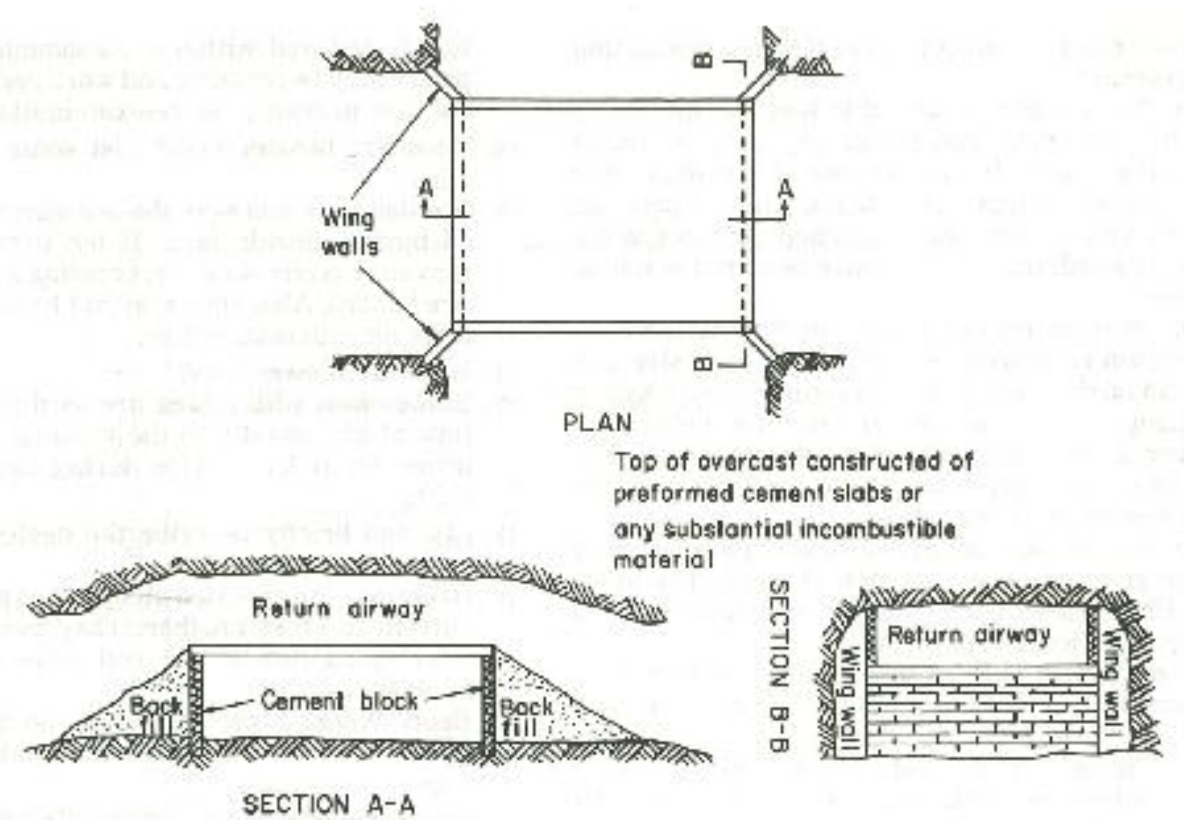
Line Brattice— A line brattice is a curtain erected from the last breakthrough, along the entry or room, to the face. Its purpose is to conduct an air current to the working face, to assure sufficient velocity of air at the face to remove dangerous gases.

The line brattice should be placed on the intake side of the room or entry, and the space behind is maintained clear and open for the free flow of air. As far as possible, the line brattice should be nonflammable (non-burning).

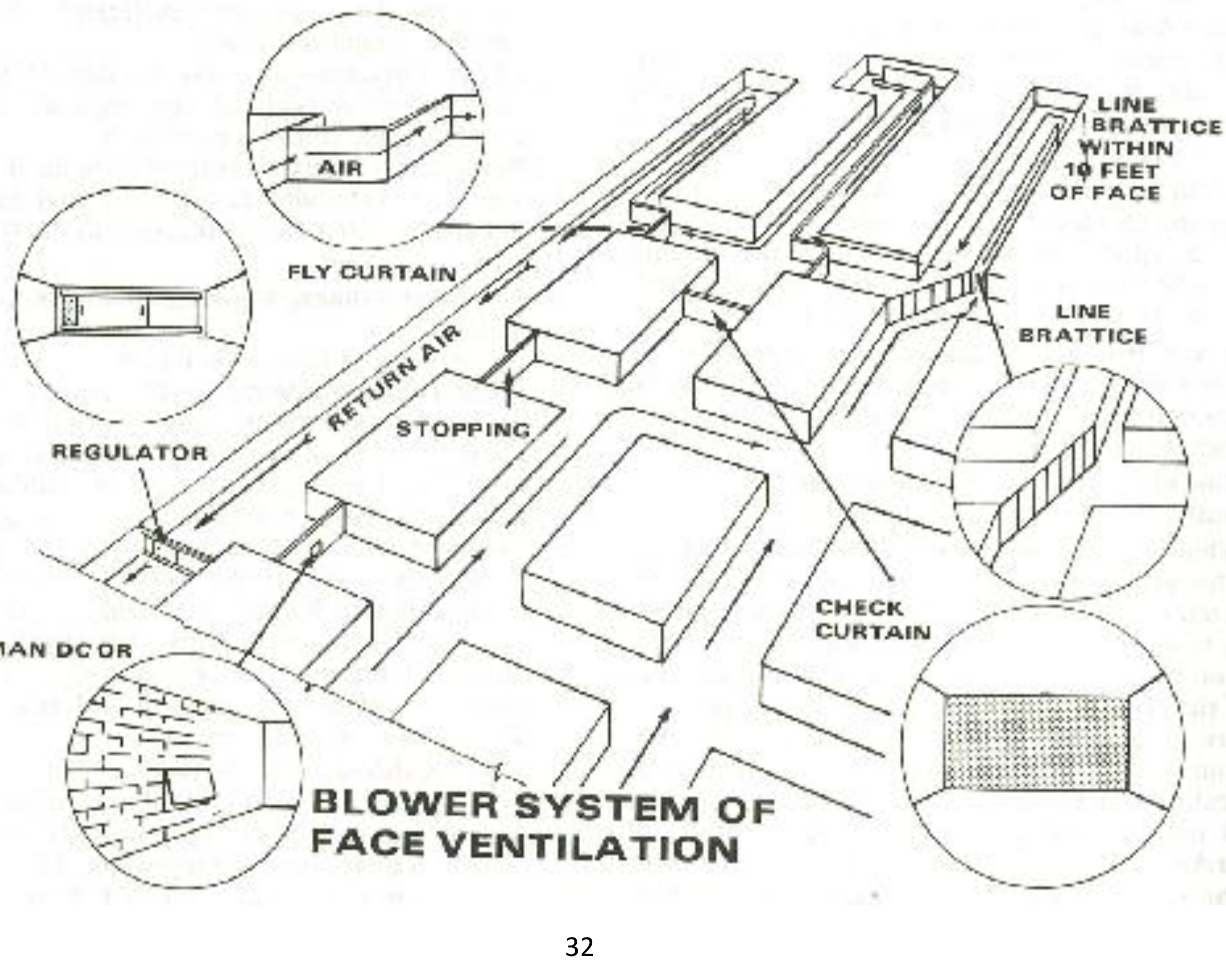
Check Curtains—Check curtains deflect the air current into working places. They should only be used where leakage is not serious; temporary doors are preferred where possible.

Regulators—A regulator is an adjustable, partial obstruction in an airway. It is often a stopping with an opening having a sliding door.

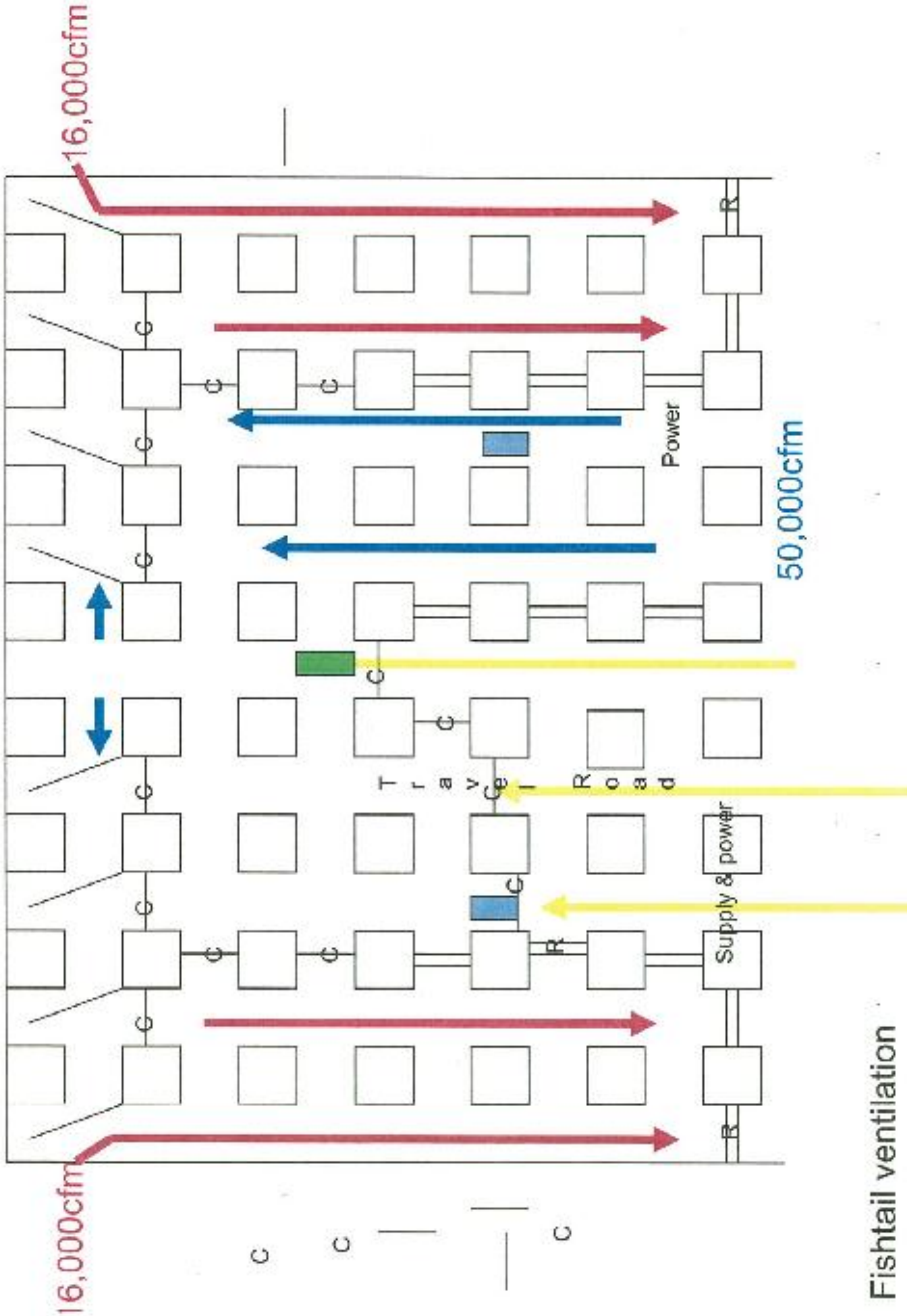
A regulator in a split decreases the quantity of air entering that split, the amount depending on how open or closed the sliding door is kept. They are placed in the splits having the least resistance to air flow. The smaller the opening left open, the greater the resistance to air flow, and air is “forced” down the other splits.



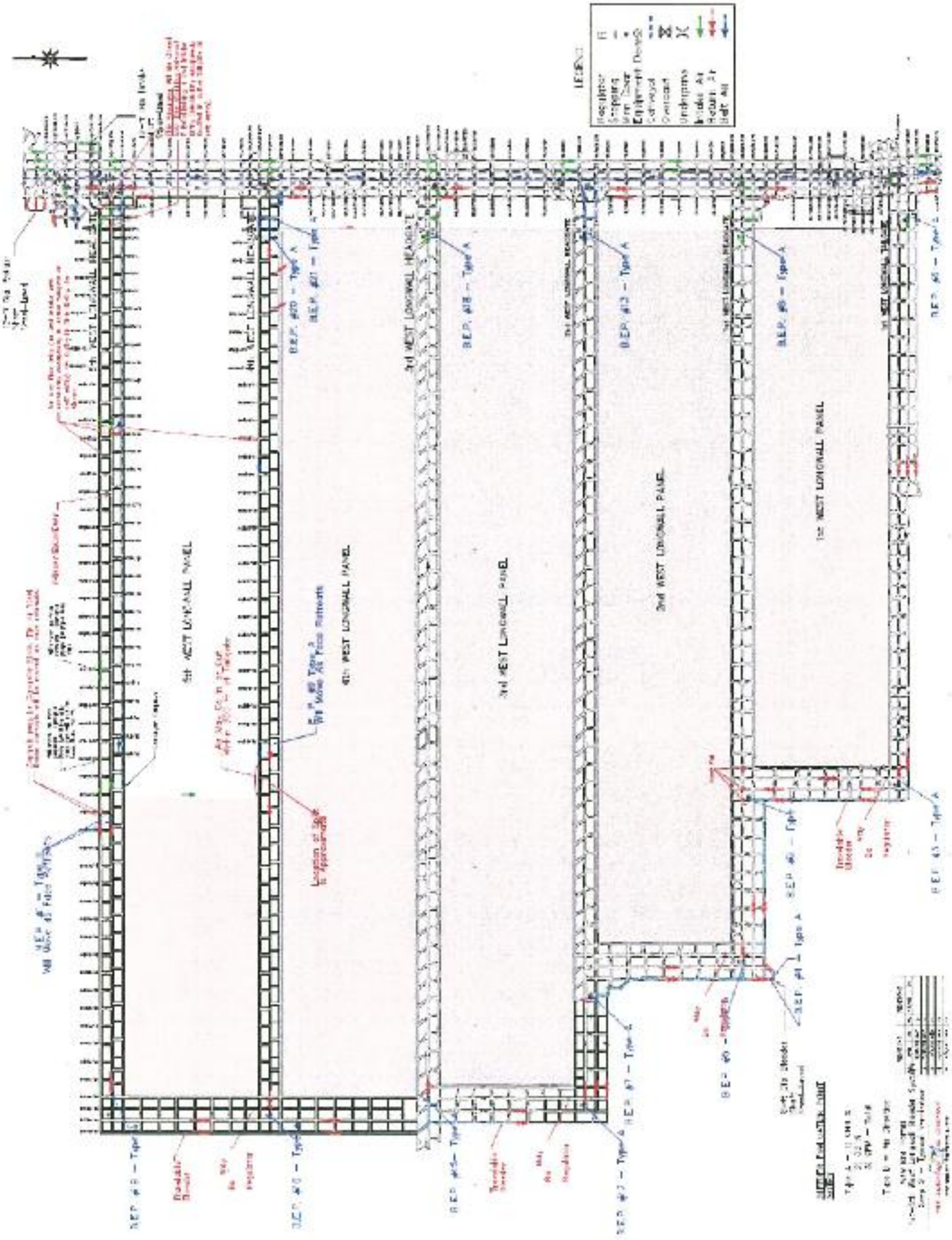
HIGH CAPACITY OVERCAST



BLOWER SYSTEM OF FACE VENTILATION



Fishtail ventilation



LEGEND
5th WEST LONGWALL PANEL
4th WEST LONGWALL PANEL
3rd WEST LONGWALL PANEL
2nd WEST LONGWALL PANEL
1st WEST LONGWALL PANEL

LESSON F

Instruments—Thermometers, Hygrometers, Barometer, Water Gauge; Velocity—Anemometer Velometer

Instruments

So far we have discussed the different characteristics of mine air; temperature, humidity, pressure, velocity, and the various gases that can be found. Now we turn to instruments that measure these characteristics.

Some of these instruments are very simple to operate, some can be very complicated. It is important for the mine examiner to be able to use all of them, for it is with them that he can determine the safety of the mine. A mistake may endanger the safety of the men working underground—proper and accurate measurements are essential.

Temperature

Almost everybody is familiar with the thermometer, used to measure temperature. It consists of a bulb, usually filled with liquid mercury, connected to a hallow tube. Liquid mercury expands as it heats and contracts as it cools. As the temperature increase, the mercury expands and flows up the hollow tube; as the temperature decreases, the mercury contracts and will flow down the tube into the bulb.

The amount of mercury in the tube is thus a measurement of the temperature. There is a scale alongside the tube to give a reading in degrees.

Humidity

Humidity, the amount of moisture in the air, is measured by one of several types of **hygrometers**. Hygrometer comes from Latin: hygro- means water, and meter means measure.

One often found hygrometer uses two thermometers, one whose bulb is kept dry and another whose bulb is kept wet by a water-soaked cloth. As the water evaporates, it cools the "wet-bulb" thermometer; the more water that evaporates, the cooler will be the "wet-bulb."

Pressure

Atmospheric pressure is measured by a **barometer**—usually an aneroid barometer. (There is also another type, a mercurial barometer). Changing atmospheric pressure causes one side of the instrument to move. This movement is shown as a change on the front dial which is marked off in equivalent inches **of mercury** (to give the same result as a mercurial barometer). Each inch of mercury is equal to .49 pounds of pressure per square inch.

When we descend into a mine, there is a greater weight of air pushing down—the atmospheric pressure increases, and so does the reading on the barometer. The reverse happens when we ascend—the atmospheric pressure decreases, and so does the reading on the barometer.

A falling barometer means decreasing air pressure, which permits air to expand. This may permit gases in large abandoned areas to expand into active workings.

Ventilating pressure is measured by a **water gauge**, which is a glass U-shaped tube, partially filled with water, open at both ends. The water gauge actually measures difference in air pressure; it measures ventilating pressure when one end is held towards the fan and the other away from the fan. Each inch difference in the height of water in the two columns is equal to 5.2 pounds per square foot of pressure.

Water gauges may also be placed with the air intake end through adjustable openings in doors and stoppings to determine the pressure of the doors and stoppings.

The absolute pressure on air in the mine is the sum of atmospheric pressure plus ventilating pressure.

Velocity

The velocity of the air current is measured by an **anemometer**. There are two commonly found types of anemometers—the “standard” rotating vane anemometer, and the velometer.

The standard anemometer resembles a small disc fan—a metal ring surrounding a set of rotating blades. The air current striking the blades causes them to rotate—the anemometer is geared so that one full rotation is equivalent to one foot of air travel. Holding the anemometer in the air current for sixty seconds will give you the velocity in feet per minute; for 120 seconds the velocity in feet per two minutes (divide by 2 to get the velocity in feet per minute), etc.

To operate, hold the anemometer away from your body so that the full current will enter it, with the back of the instrument towards the source of air (usually the fan). Use the reset lever so that all dials will be at zero, and release the brake to allow the blades to rotate freely. Expose the anemometer to the air for one full minute, timed with a stopwatch, moving about to obtain an average reading for the sectional area to be measured. At the end of the minute apply the brake, and read the velocity from the dials.

Care must be taken in timing the exposure of the anemometer to the air current. If the reading was supposed to be taken for sixty seconds, each second off gives a reading error of 1/60 or 1.6%. If the velocity is fairly high, the error can be significant.

If the velocity is 500 feet per second, and the reading is accidently taken for 63 (instead of 60 second), the reading will be in error by 5%, or 25 feet per second.

A second type of anemometer is known as **velometer**. It is the size of a pack of cigarettes, and gives direct velocity readings—no timing is necessary.

1. Select the “hi” or “lo” range by rotating the selector on the side of the velometer.
2. Hold the air inlet pointing towards the source of current. Make sure you are not blocking either the air inlet or outlet.
3. Read the velocity from the appropriate scale.

Problems

1. **What instruments are used to measure the following air characteristics?**
   Temperature, Pressure – Atmospheric, Humidity, Velocity, Pressure – Ventilating.

   A. Thermometer; hygrometer; water gauge; barometer; anemometer (and velometer)
2. **How do you read the above instruments?**

   A. Thermometer; barometer; hygrometer anemometer; water gauge (and velometer)

   Hygrometer—take the wet bulb and dry bulb readings; get the humidity from a table.

   Water gauge—read the difference in height of the water columns; each indifference means 5.2 pounds per square foot of pressure.

   Barometer—read the pressure (in inches of mercury) from where the pointer rests on the scale in front.

   Anemometer—read the dial in front after taking your measurements.

   Velometer—see where the pointer rests, and read the velocity from the scale—using the proper range.

LESSON K

Roof Control: Proper roof testing, No. 1 Killer, Conditions contributing to bad roof; Causes of falls; Major Faults and Intrusions; Visible Signs of Dangerous Roof; Two principles of roof Bolting

Proper Roof Testing

Proper roof testing should be done in the following manner:

1. First, make a visual examination of the area. If you can see the roof is bad, testing is not necessary.
2. Always stand under supported roof when testing.
3. Test only far enough to erect the next supports in face areas.
4. Always start from supported roof and examine toward the face.
5. Never turn your back to the face or ribs while testing.
6. Always use bare fingers against the roof with your thumb pointing toward you. (This will make it difficult for you to walk out under unsupported roof.)
7. Start tapping the roof lightly at first with your surrounding rod; then increase your stroke to hear the sound of the roof and/or feel the vibration.
8. Always use an approved testing tool.
9. Always use goggles or safety glasses to protect your eyes.
10. Test the roof frequently while working (Roof conditions frequently change.)
11. Test closely for cracks , slips, kettle bottoms, horsebacks, or irregular formation
12. Always test the ribs and face in addition to the roof.
13. Always test the roof, face, and ribs before all work is started.
14. Use a sturdy bench or long testing tool in high places.
15. Always be sure of a safe line of retreat.
16. Take your time and be sure that you have made it through examination.
17. Remember that roof testing is not fool proof. Caution should be exercised at **all** times!

Visible Signs of a Dangerous Roof

1. Slips or cleavage planes and fractures
2. Spalling of coal from the rib
3. Changes in texture of rocks from one kind to another
4. Rolls, kettle bottoms, or bells
5. Bending of crossbars and props
6. Squeezing of cap pieces down over the props
7. Bits of bark loosened by pressure on the props or timbers
8. Unusual wetness of the rock, or moisture laden rocks
9. Unusual liberation of gas (pressure)
   a. Statistics of fatal and nonfatal injuries to demonstrate the hazards from falls of roof and rib.
   b. The most hazardous part of a coal mine is within 25 feet of the working face.
10. Roof Structure:
    a. Primary roof is the main roof overlying the coal bed.
    b. Secondary roof is the immediate roof above the coal bed.

11. Conditions contributing to bad roof and rib:
    a. Stresses resulting from extraction.
    b. Defects in overlying strata:
        (1) Pots, clay veins, kettle bottoms, fossils, horsebacks, rolls, "slickenside," draw slate.
        (2) Faults, fissures, cavities
    c. Pressures from:
        (1) Gas.
        (2) Water.
    d. Air Changes:
        (1) Moisture.
        (2) Temperature.
12. Roof inspection and testing:
    a. Visual inspection.
    b. Sound-and-vibration method.
    c. Other methods.
    d. Limitations of roof testing methods.
13. Methods of supporting roof:
    a. General.
    b. Timbering—conventional:
        (1) Definition of the method.
        (2) Requirements for timbering
        (3) Special timbering problems.
        (4) Advantages of timbering.
    c. Roof bolting:
        (1) Principles and extent of roof bolting
        (2) Proper installation:
            Specifications for bolt installation.
                (b) Advantages.
    d. Roof truss.
14. Causes of fall of roof and rib:
    a. Improper evaluation.
    b. Insufficient and improper support.
    c. Excessive pressures.
    d. Removing timber and rock.
    e. faults, fissures, bumps.
15. Roof control plan:
    a. General.
    b. Spot roof bolting plan.
    c. Pillar recovery plan and methods.
    d. Open end pillaring
16. Role of mining personnel in preventing falls of roof and rib:
    a. Duties of supervisors:
        (1) Examine working areas thoroughly.
        (2) Adhere to adopted roof and rib control plan.
        (3) Instruct men concerning roof and rib plans.
        (4) Train timber men and roof bolters.
        (5) Supervise proper installation of roof supports.
        (6) Do not advance beyond support roof in face areas.
        (7) Alert fellow worker.

Conditions Contributing to Bad Roof and Rib

Stress Resulting From Extraction

When underground openings are made for the removal of coal, the balance of the stresses in the roof and ribs changes and unsupported immediate roof will have a tendency to usually sag in the center. The sagging may continue until failure occurs unless:

1. Support is provided to prevent the failure.
2. The strength of the roof material is such that it can support itself after the sag reaches a certain point.

The type of support needed varies with the mining method; this includes advance or retreat, complete or partial pillar extraction and with the materials over the coal. What mining personnel have considered “good” roof is often recognized as not dependable, because most roof has undesirable qualities. The materials composing the roof strata are major factors in determining its strength.

Two major theories of mine roof control have been developed and used to arrive at solution of roof control problems. These are the pressure arch theory and the beam theory. Their usefulness depends on the nature of the rood and the depth of the overburden.

Weakening of the coal rub, even by undercutting, quite often will be sufficient to cause pillar failure. This causes the roof to fall unless support had been installed.

Defects in Overlying Strata

The roof may have slip planes or cracks, “kettle bottoms” or fossil stumps, inverted “horse backs” and clay veins. The presence of slip planes and fossil stumps is often concealed by a thin layer of coal. Slip planes or cracks in the roof may cause a large part of the roof to fall immediately after the coal has been blasted or while the coal is being loaded. “Kettle bottoms” or fossil stumps are not often discovered until they have fallen. Inverted horsebacks are usually recognized as they are shaly and hang below the level of the roof. Clay veins that cut into or through the coal bed break the continuity of the roof. Roof materials are likely to fall when approaching or leaving the position of the clay vein. Under such conditions all roof should be treated as hazardous and adequate posts or roof jacks should always be set before installing permanent roof support.

Faults, fissures, and cavities are generally larger roof defects which are normally found in the secondary strata. Determining these roof abnormalities is an engineering function. There are some occasions when these major faults extend into the coal seam. If fissures or large faults intrude the mining seam of coal, the entire face disrupted or offset and frequently disappears completely. The extent of disruption of the seam depends upon the size of the fault.

Pressure from Elements

Gas

In some mines the overlying strata contains gas under pressure. When the coal is removed, pressure causes the roof to bend, crack, and frequently, to fall. Under some conditions removal of coal, with the consequent exposure of the roof material to the air, causes moisture to deposit on the roof material which penetrates cracks and crevices weakening the roof and ultimately causing the roof to spall. This is generally called “snap roof”. Gas is often present in the bottom strata and occasionally causes the bottom to heave. In several mines, pressure has been so great that gas has burst from the bottom and caused a crevice.

Water

Water

In the overlying strata is a sign that the various layers have separated sufficiently to indicate caution in providing roof support. Water dripping from both the roof and sides can make the floor slippery, particularly for workmen carrying or installing roof supports or other material.

Air Changes

The combination of moisture and temperature in the mine air causes the roof and sides to deteriorate. As warm, humid air enters a mine, it cools off and moisture deposits on the mine surfaces. In many mines the water penetrates into cracks and slips and loosens the overlying strata, usually through swelling of the material that it absorbs.

Limitations of Roof Testing Methods

There is no sure method for determining mine roof conditions that cannot be seen. Some hazardous conditions (faults, fissures, rolls, concealed kettle bottoms, etc.) may remain hidden until the roof begins to move, thus causing serious accidents. Results of roof testing by the sound-and-vibration method are not always distinguishable or reliable and many rocks are difficult to classify as "drummy" or "solid". If it is thick enough, a dangerous piece of rock will sound as though it is solid (musical instead of dummy). If the condition of the roof is doubtful, extra precaution should be taken when installing the necessary support.

Questions with Accepted Answers

For Practical Coal Mining Classes

Causes of Falls

1. **Q. What factors contribute to falls of roof?**

   A. The thickness and character of the strata that comprise the roof, the weakness of the coal pillars that support the span of exposed roof, and the number and manner of placing roof supports, contribute to falls of roof.
2. **Q. Where does the roof tend to break first?**

   A. The first failure usually is a tension crack at the point of maximum sag of the beam, but the final failure of the roof usually is shearing at or near the rib.
3. **Q. Does roof generally break without warning?**

   A. No, but the warning signs may not be readily seen or heard.
4. **Q. Does the time of exposure affect roof action and subsequent falls?**

   A. The longer the roof is unsupported, the greater the opportunity for the immediate roof to sag and permit air to penetrate to the upper strata. Weathering tends to break down the cementation between the strata; such action is cumulative.
5. **Q. When is the proper time to support the roof?**

   A. Roof should be supported as soon as possible after excavating. It is unwise to wait for the roof to sag or "take weight". In other words, the more efficient practice is to use supports to prevent sag rather than to use them to hold the "dead weight" or rock that has failed – setting props immediately after coal excavating, if the roof bolters are behind in their cycle or during a change of shift.
6. **Q. What preparation is required to support a bad piece of roof safely and efficiently?**

   A. Careful testing of the roof, starting at a safe place, is the first essential to ensure the safety of the workmen; safety props should be set as the work advances. Many mine accidents occur while men are digging hitches or doing other work preparatory to setting props. One or more safety posts or props would protect them while doing this. Workmen must be instructed not to stand under a piece of roof while testing, trimming, digging hitches, or doing any other work in connection with their jobs.
7. **Q. What should be done to protect miners from hidden roof dangers?**

   A. The best precaution is to consider all roof dangerous and always insist on adequate roof support. Good workmanship in placing and spacing roof support is a very important factor.
8. **Q. In what part of a coal mine do most accidents from falls occur?**

   A. Approximately 85% of all accidents from falls of the roof, face and ribs occur within twenty-five feet of the face.
9. **Q. What is the first important step to prevent accidents and injuries from falls of roof?**

   A. The adoption of a program systematic roof control that demands concerted effort of the entire personnel of the mine to reduce accidents from falls of roof and coal. The program should be so flexible to where it can be adjusted to meet and unusual occurrence.
10. **Q. Is it advisable to set temporary props before taking down loose roof?**

    A. Yes. Unless the surrounding roof is exceptionally firm, it is advisable to set temporary props before taking down loose roof.

11. **Q. What precautions should be taken when a crack or slip is discovered in the roof?**
    A. Substantial props or cross bars should be placed on each side of or across the crack or slip. The roof adjoining the slip may be in the form of a cone; therefore, it is advisable to keep a sharp lookout for the appearance of another slip during removal of the coal. If roof bolts are the primary roof support, it is necessary to increase the number in spacing, use a longer bolt for adequate anchorage, or displace the roof bolts with crossbars and props, or a combination of properly installed roof bolts and crossbars.

Roof Control in Mechanized Mining:

12. **Q. In mechanized mining, what difficulty is usually encountered in providing adequate roof support at active faces?**
    A. The smallest mobile cutting and loading machines require considerable space free of props to operate to best advantage. The roof above this open space must be supported or secured for the safety of the workers and yet not interfere unduly with operation of the machines. The continuous mining and loading machines recently developed open excavations much more rapidly than the older methods of mining; they call for methods of roof control that provide the greatest safety and conform with the mining cycle.
13. **Q. Should roof be supported where men are required to work with mobile equipment?**
    A. Yes. Ample support should be provided for the safety of the operators of the equipment and for others who are required to work at or near the face. Noise made by the machinery used near the face often prevents the workmen from hearing the preliminary chipping or cracking of roof; therefore, adequate roof support is especially important in mechanized mining.
14. **Q. What supervision and precautions are necessary for safety in mechanized mining?**
    A. In mechanized mining it is possible to obtain the desired production with a much smaller number of men and fewer working places than in hand mining. This usually permits much more concentrated mining and closer supervision. On the other hand, more workers are exposed in each working place to hazards from bad roof, moving machinery, electrical cables, wiring and electrical equipment, gases from the strata and from breaking down of the coal. Such hazards require that supervision be more intensive and efficient than in hand mining. A face boss should examine every working place for possible dangers, including explosive gas, before men enter and also before mining or loading machine enters and after it leaves the place. The preliminary examination should supplement the earlier mine examiners examination; accidents have occurred because face bosses and mechanized mining crews have relied on an examiner's report than conditions were safe some hours before.
15. **Q. What are the duties of the face boss with respect to systematic timbering?**
    A. A face boss should see that the roof is supported safely. He should see that the method of roof support adopted for the mine is followed and that the necessary supplies for doing the work are available and convenient at all times to the working face and where required elsewhere. He should insist on good workmanship and proper anchorage of roof bolts.
16. **Q. When should permanent roof support be installed in a working place?**
    A. Permanent roof support should be place as soon as possible after a loading machine has completed loading the coal, before other employees other than roof control men, enter the place. This will protect all other face personnel who are required to work in the place to complete the cycle of operations before loading is resumed.
17. **Q. Should operators of mobile mining or loading machines remove safety props or other means of roof support with the cutter bar of a mining machine or the head of a loading machine?**
    A. No. such practice is dangerous and has caused numerous fatalities. No method of roof support should be removed, adequate adjustment to support the roof beam must be made, and then the initial roof support removed, and this should be done under proper supervision with competent personnel.
18. **Q. What precautions should be observed in drilling and blasting or breaking down coal in mechanized mining?**
    A. Holes should not be drilled too near the roof because the method of breaking down the coal may break the roof and cause it to loosen or fall and endanger the loading machine crew. When the coal is not broken properly, the operator must dig it with the loading machine. Such practice sometimes results in the loading boom swinging accidently and dislodging safety props.
19. **Q. How do temporary supports prevent accidents and injuries from falls of roof?**
    A. Temporary supports provide protection against unseen roof weaknesses as they develop until the face has advanced far enough to permit the erection of permanent supports.

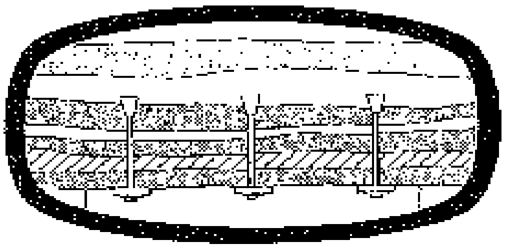
20. Q. Who is charged with the responsibility to see that working places are properly timbered under the Coal Mining Act?

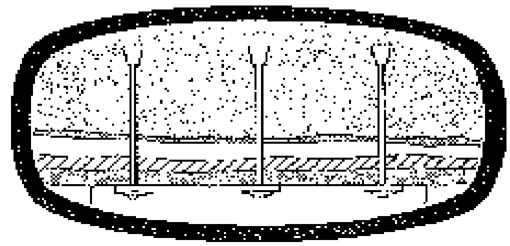
A. The operator of every mine shall see that necessary and proper supports are provided for the roof in all working places, and in all entries and air courses where men are required to travel to and from any working place, and shall see that all such places underground are properly timbered.

Every miner shall sound and thoroughly examine the roof of his working place before commencing work, and if he finds loose rock or other dangerous conditions, he shall not work in such dangerous place except to make such dangerous conditions safe.

Every miner shall properly prop and timber in a skillful and workman-like manner, in order to secure his place for his own safety, with materials provided therefore by the operator in lengths as required by the Act. The miner shall have the necessary tools to enable him to comply with the provisions of this section.

TWO PRINCIPLES OF ROOF BOLTING





LAMINATION

The roof bolts provide support by creating beams of the different strata – bolts are used to bind these strata together much like the manufacture of plywood.

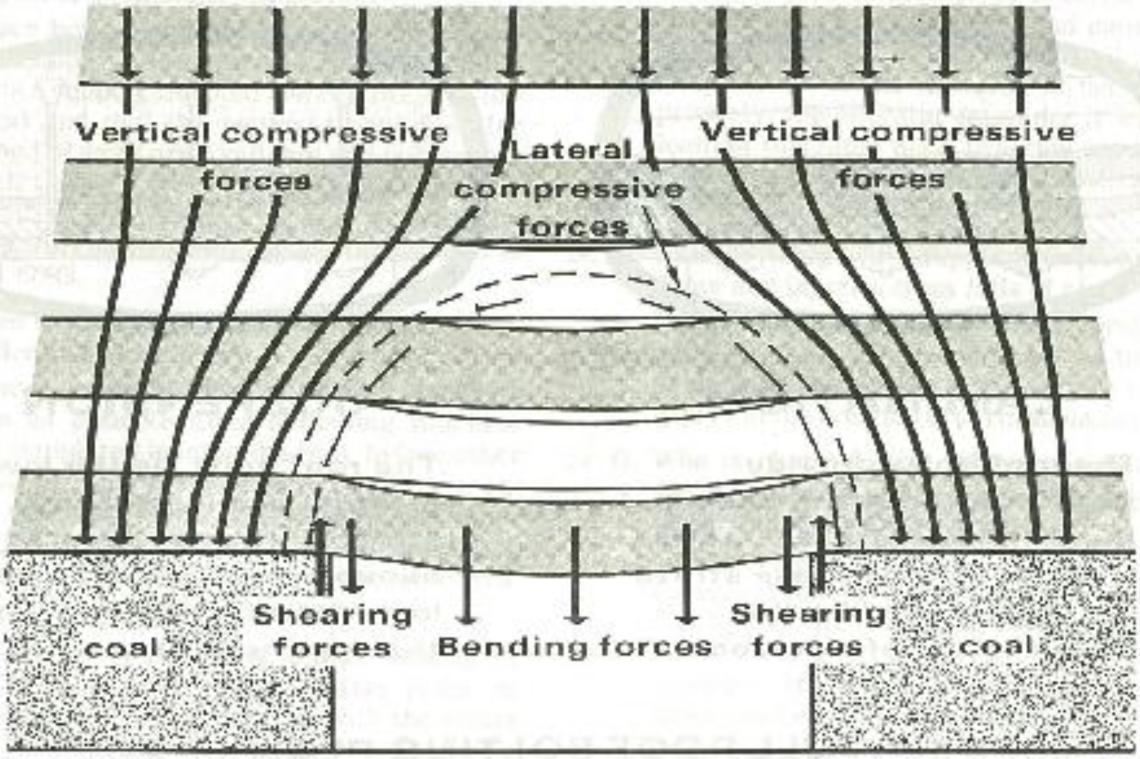
SUSPENSION

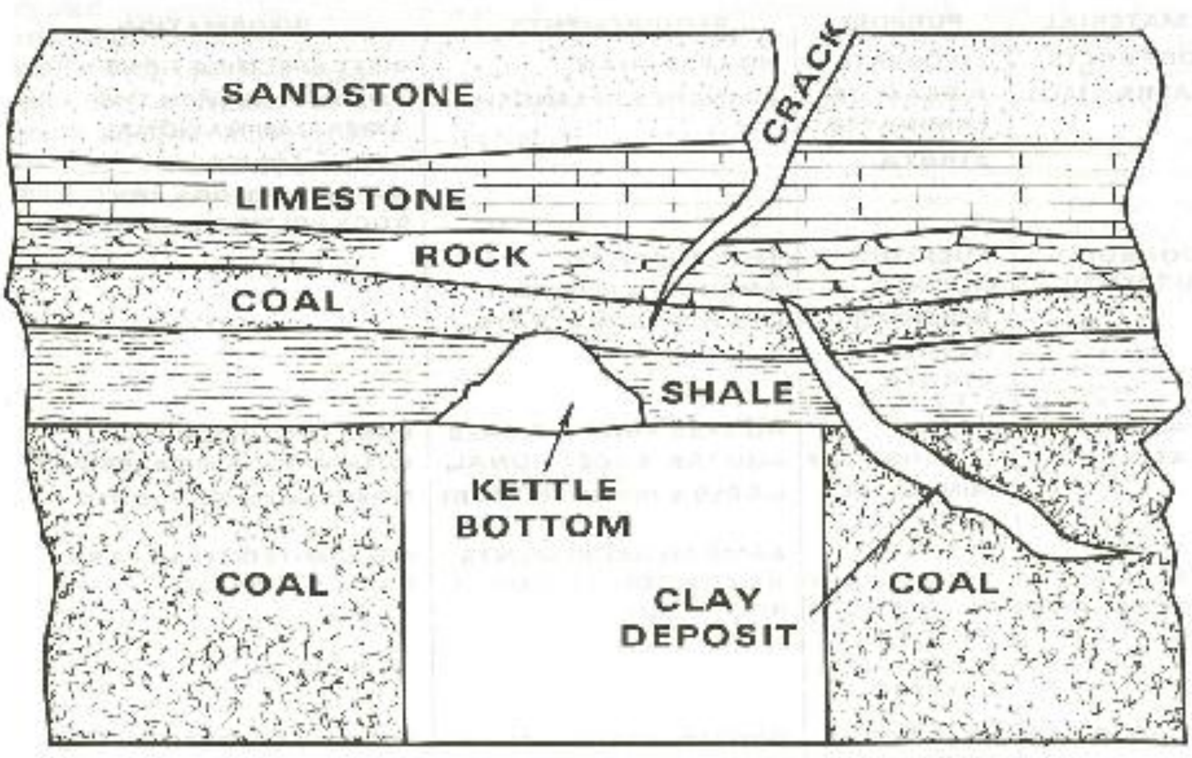
The roof bolts tie the lower stratum of the roof to a stronger stratum located above the main roof. The lower stratum hangs from the upper stratum.

FULL ROOF BOLTING PLAN
<u>ACCORDING TO SPECIFIATIONS</u>

MATERIAL	PURPOSE	REQUIREMENTS	INFORMATION
ROOF BOLTS (LAMINATED)	TO CREAT A BEAM OF LAMINATED STRATA	NO LESS THAN 30 INCHES IN LENGTH	MEETING SPECIFICATIONS COMPLYING WITH THE AMERICAN NATIONAL STANDARDS INSTITIUTE, SPECIFICATIONS FOR ROOF BOLTING MATERIALS
ROOF BOLTS (SUSPENSION)	SUSPEND ROOF TO STRONGER OVERLYING STRATA	THE LENGTH TO ANCHOR 12 INCHES IN STRONGER STRATA	DO
BEARING PLATES	USED AGAINST THE MINE ROOF	NO LESS THAN 6 INCHES SQUARE; EXCEPTIONAL CASES 5 INCHES SQUARE	USED IN CONJUNCTION WITH WOODED MATERIALS NO LESS THAN 4 INCHES
PLANKS, HEADER BLOCKS, AND CROSSBARS	BETWEEN THE BEARING PLATE AND ROOF FOR ADDITIONAL BEARING	SAME MEASUREMENTS AS FOR CONVENTIONAL ROOF PLAN	USE LIMITED TO 3 YEARS UNLESS TREATED
WASHERS	USED WITH ROOF BOLTS	CONFORM TO SHAPE OF ROOF BOLT HEAD AND BEARING PLATE	SUFFICIENT STRENGTH TO WITHSTAND LOADS UP TO YIELD POINT OF ROOF BOLT

DISTRIBUTION OF FORCES IN THE VICINITY OF A NARROW OPENING





MINE STRATA WITH FAULTS AND INTRUSIONS

LESSON L

Mine Fires, Procedure Following Fires, Unsealing Mine Fires, Mine Explosions, Maps, State Inspection of a Mine

Procedure Following Mine Fires

Methods of Controlling and Extinguishing Mine Fires

Fighting Mine Fires by Direct Attack

Water may be applied by hoses in large streams of fine spray.

a. A perforated pipe or nozzle connected to a hose may be pushed gradually ahead into the active fire.
b. If a great quantity of water is applied to a roaring flame, steam and hydrogen may become hazards. The hydrogen may explode.
c. Water may be used to cool; it does not extinguish fire in burning material which is loaded out.

Chemicals may be used to control fires.

a. Hand extinguishers.
b. Mounted extinguishers on larger fires.
c. Extinguishers may create dangerous fumes or irrespirable gases.

Fine limestone or shale dust for rock-dusting bituminous coal mines in fighting fires in the early stages and also for larger fires under some conditions.

a. Small fires may be controlled by dust applied by hand shovels.
b. Rock dusting machines may be used to apply rock to dust fires.
c. Rock dust serves to exclude oxygen from the heated area and may also serve to reduce the heat of the burning material.
d. Covering burning material with rock dust does not produce fumes as does the use of chemicals, nor does it produce steam and hydrogen as does the use of water.

Fine sand can be used in make a direct attack in essentially the same manner as rock dust.

The foam generator is an effective method of extinguishing mine fires.

a. They can be used ideally when driven down the entries to mine fires which are otherwise inaccessible.
b. Fires can be attacked from a distance as great as 500 feet in ventilated passageways.
c. Conversion of the water to steam absorbs heat by reducing the oxygen content of the atmosphere and active burning should cease.
d. The foam wets all objects which it contacts, thus making it useful only in fighting class A or B fires.
e. The foam generator is effective in fighting stubborn localized fires that are not accessible to direct attack.

Recovery Procedures Following a Mine Explosion

Examination of Mine Openings

Before exploring is begun, preliminary examination of all openings and escapeways; men overcome by afterdamp may be found near openings.

Establishing Ventilation

If the ventilation fan has not been destroyed or damaged, it should be kept running.

Unsealing Mine Fires

Experience has shown that no attempts should be made to unseal a mine fire until the oxygen content of the sealed atmosphere is low enough to make explosions impossible and until the carbon monoxide, the indicator of combustion has disappeared.

The extent and intensity of the fire at the time of sealing will have a decided bearing upon the reduction of oxygen in the area.

a. The character of the burning material; whether it is wood, bituminous coal, or anthracite; the rate of burning; and the change of gas composition may influence rekindling when air is readmitted.

b. Combustible or noncombustible roof material may retain heat for a long time after the smoldering main fire is cooled.

Barometric pressure affects sealed pressure.

Excess outside pressure causes air to enter.

Lower pressure outside assists in the escape of the sealed atmosphere (CH^4, CO, CO^2, etc.).

If the temperature outside of the mine is lower than the mine temperature, inward pressure on the fire seals is likely to occur; higher, outward pressure will occur.

As the fire cools, inward pressure results.

If the stoppings are hot or warm, the temperature within the sealed region is high.

When the pressure is outward only, samples of the atmosphere behind stoppings should be taken at least once every 24 hours for the first few days of the fire.

Using aspirator bulb or pump, samples may be collected by vacuum tube, water displacement, and air displacement.

The gases usually found in sealed regions mainly contain methane, hydrogen, carbon monoxide, carbon dioxide, nitrogen and oxygen.

It is desirable that the oxygen be reduced to at least three percent and preferably below one percent before an attempt is made to unseal.

In addition to the above, the time for unsealing may be determined by local factors gas wells, position of boreholes, extent of the region under seal, and the temperature within the sealed area.

In coal mines, methane may be emitted from the cleats or cracks of the coal, from “blowers” or “feeders”, or from the overlying or underlying strata. Methane released in large amounts from the coal when irregularities, such as clay veins, “horsebacks”, or faults.

The successful opening of a fire area necessitates certain preparations.

Adjustments in ventilation should be made to direct fire gases from the sealed region into the main return.

An attendant should be at the mine fan to see that it is to correctly operating. If the fan slows down, the men engaged in the unsealing work must be warned immediately. In bituminous coal mines, all entries and crosscuts leading to and from the fire region should be coated heavily with rock dust for a considerable distance out by the seals that are to be opened.

Mine Fires.

1. **Q. What are the chief causes of mine fires? Give full details.**
   A. The causes of mine fires are numerous. Among the chief causes are accidental ignition of gas by careless handling of open flames or matches or the use of torches or open flame in proximity to combustible materials, such as waste, oil and grease, canvas, brattice boards, etc. the short circuit of electric currents, or the blowing out of fuses, the blowing of faulty electric cables, or by the sparking of wires; belt conveyor friction; fires resulting from local explosions of gas in waste and abandoned places in the mine.

2. **Q. As a mine manager or foreman how would you proceed to guard against mine fires?**

   A. The best safeguards against mine fires are the prompt removal of the possible causes of fires, by loading out all fire coal and coal dust, proper insulation of wires and cables that pass through stoppings, over belts, and protected lights in pump rooms and other places near combustible materials. Also the strict compliance of the mining laws with reference to ventilation, gas, and rock dusting.

3. **Q. What are the chief causes of belt conveyor fires?**

   A. 1. Head drive units are not kept clean and poorly aligned.
   2. Broken or "frozen" rollers causing belt friction.
   3. Torn or frayed belting getting caught in tail or head drive sections
   4. Reversing belt, with coal on same, belt tail section becoming fouled.
   5. Moving pans or other equipment over belt such equipment coming in contact with power wires.
   6. Accumulations of fire coal around belt rollers and friction igniting coal.
   7. Falls of rock, or coal or rib coal fouling the belt causing excessive friction at the head or drive section; friction igniting the coal, or the belt.
   8. Falls of rock or coal causing power cables to come in contact with the belt or other combustible materials.
   9. Belt control switches not operating properly.
   10. Excessive amounts of greases or waste oil permitted to accumulate at drive rollers, and at tail section

4. **Q. Under what conditions would you seal off a mine or a section of a mine to extinguish a fire?**

   A. For the purpose of extinguishing a fire in a mine or in a section of a mine, recourse should be had only when every other possible means has been employed to put out the fire, and the latter has gained in any one section such headway as to menace adjoining portions or sections of the mine.

5. **Q. What are the purposed of sealing off fire areas in a mine?**

   A. The object of sealing off a fire area in a mine is, primarily, the extinction of the fire by preventing the access of fresh air, which is necessary to maintain combustion. Another purpose is to prevent the contamination of the mine air with the gases produced by the fire. A third purpose is to prevent the spread of the fire to adjoining workings.

6. **Q. How would you determine when the purpose of sealing off a fire area had been accomplished?**

   A. The effectiveness of the fire seals on the progress of the fire is carefully watched by testing the nature of the gases given off through the pipes built into the seals. The character of these gases and their temperature will eventually determine when the sealing off of the area has accomplished its purpose.

7. **Q. How would you approach the burning section of a mine; and, in case the condition necessitated the sealing off of the burning section, what steps would you take to insure the safety f the workers and the success of their work?**

   A. The burning section must be approached from the intake side, in order to avoid the danger of being overcome by the gases produced by the fire. Should it be necessary to seal off the burning section, the men should be promptly withdrawn from the mine and only such persons to be permitted to enter as are required for the work of building the seals. A danger sign must be placed at the entrances of the mine and such entrances carefully guarded to prevent anyone from entering, except those engaged in the work. In building the seals, every precaution should be taken to insure safety. The electric power should be turned off in the mine and only closed lights used. The seals should e built in such a manner and order as will reduce the danger of an explosive gas mixture forming in the enclosed area, to a minimum.

   In general, the first seal should be started at the return end and the work proceeded in regular order from that point to the intake end. Some will prefer to leave a small opening in the seal at the return end and close this at the same time that the intake seal is closed. All seals must be well built and carefully plastered for air-tightness, and pipes should be built in, at the floor and at the roof, to allow for drainage and for inspection of the condition of the air from time to time, as may be required.

8. **Q. Under what conditions is it safe for men to enter airways contaminated by gases emanating from a mine fire?**

   A. No one should be permitted to enter an airway that is filled with gases generated by a mine fire, unless he is protected by an approved form of breathing apparatus. There is always a large amount of carbon monoxide produced by the fire, and this gas is very poisonous and may produce instant death if present in sufficient proportion in the air current.

9. **Q. By what mean can the condition of the fire in a sealed area be indicated?**

   A. By analyses of air samples taken from behind the seals by means of pipes built into the seals. These analyses should not show that there is no carbon monoxide, the oxygen reduced to a very low percentage, at about one percent. There will very likely be a high concentration of carbon dioxide and methane gases in the analyses of the samples. A content of carbon monoxide and a continued high oxygen content shown in these analyses would indicate that the fire is still active in the sealed area. It is not advisable to unseal a fire shortly after the carbon monoxide has disappeared and the oxygen content is reduced to a low percent because of the danger of the fire rekindling. Sufficient time, twenty-four to forty-eight hours, should be allowed for the area to cool to minimize the danger of rekindling.

10. **Q. What is the Illinois mining laws with regards to fire prevention and fire control?**

    A. See Article 21, The Coal Mining Act.

Mine Explosions

1. **Q. When is it possible to have an explosion in the coal mine with no methane present?**

   A. When the quantities of coal dust are raised in sufficiently dense cloud in the presence of a source of ignition.

2. **Q. What is minimum amount of coal dust is sufficient to propagate a coal dust explosion?**

   A. One-twelfth of an ounce of very fine dust per cubic foot of air.

3. **Q. What are the principle causes of explosions of gas and coal dust in coal mines, and what precautions and measures should be taken to prevent them?**

   A. Some of the common causes of explosions of gas and coal dust in mines are as follows:

   1. Inadequate ventilation allowing the accumulation of gas in working places and void or abandoned portions of the mine.
   2. Lack of thorough inspection and removal of accumulation of gas and coal dust.
   3. Blownout or windy shots.
   4. Excessive use of explosives; overcharging of holes.
   5. Insufficient stemming or stemming with coal dust or other flammable materials.
   6. Failure to use permissible explosives.
   7. Incompetent employees to examine, charge and fire all shots.
   8. Open flame, use of matches and smoking in a gaseous mine.
   9. Failure to properly ventilate the abandoned workings of amine.
   10. Lack of mine discipline and disregard of the provisions of the state mining laws; and finally, failure to enforce mine rules and regulations.

   To prevent, as far as possible, the recurrence of these disasters, strict mine discipline is required; also a thorough inspection of the mine at regular intervals, by competent mine examiners, and a strict compliance with all mining laws and regulations, by mine officials and mine workers, are absolutely necessary. Where conditions require, all shots should be fired by competent shot-firers who are authorized to examine, charge and fire all shots that in their judgment are safe. A reliable and adequate system of ventilation must be provided and the roads, airways and working places of the mine kept free accumulation of gas and coal dust.

4. **Q. Give several mean that may be taken to prevent coal dust explosions?**

   A. Keep haulage roads, conveyor belt lines, and passageways as clean and free of coal dust as possible. Sprinkle roadways, keep mine adequately rock dusted, and prevent accumulations of methane by proper ventilation.

5. **Q. What effect, if any, does bituminous coal dust suspended in the mine area have on an explosion of fire damp?**

   A. The presence of fine bituminous coal dust suspended in the mine air has the effect to extend the flame of a firedamp explosion and increase the force of the explosion, by reason of carbon monoxide distilled from the dust by the flame of the burning firedamp. The result is that an otherwise local explosion of gas may develop into a disastrous dust explosion extending more or less throughout the mine.

6. **Q. Why does an explosion in a mine render the air therein dangerous to life and health?**

   A. The gases resulting from an explosion in a mine a chiefly carbon dioxide and carbon monoxide because of the limited supply of air in the presence of rapid combustion; these irrespirable and poisonous gases and the nitrogen remaining after the oxygen of the air has been consumed by the burning constitute the afterdamp of an explosion and render mine are dangerous.

7. **Q. At what season of the year are mines that are dry most dangerous?**

   A. In the winter season; the intake air current has a temperature below that of the inside of the mine, and as a consequence when the air passes through the mine it increases its capacity to absorb moisture. This has the effect of rendering the mine workings dry and dusty to increase the danger due to the fine dust being raised and held in suspension in the mine air. In the summer season, the temperature of the intake current is generally higher than that of the mine, therefore does not have a drying effect as it passes through the mine.

8. **Q. How would you proceed to remove a large body of explosive gas from a mine?**

   A. Allow no men to enter the mine except those necessary to remove the gas; only experienced men under close supervision of a foreman should be used and with only permissible electric cap lamps and flame safety lamps. Removing large quantities of explosive gas is very hazardous and great care taken while ventilation is increased. The air current must be under complete control at all times.

Supplemental Lesson, Mine Managers, First Class and Mine Inspectors on Laws— Annual Mine Maps, Abandoned Mine Maps, Requirements for Closing Abandoned Mine Shafts, Slopes and Drifts and the Scope of Inspections Made by Inspectors

Mine Maps. The operator of each operating mine shall once each twelve months furnish an up-to-date map to the state mine inspector, the county recorder or the county where the mine is located, the mine rescue station for that district and a copy on file or displayed in the mine office. These maps must be accurate and show all extensions of the past year's workings and a separate map must be made for each seam of coal being mined. It shall have a certificate of the mining engineer or surveyor making the map ascertaining as to its correctness. Such maps shall show a north point and be made on a scale of not more than 400 ft. per inch; all measurements shall be in feet and decimals of feet. At reasonable intervals elevations of the floor of the seam shall be shown starting at the bottom of the main shaft or slope bottom of elevations of the main entries and faces of the workings. Each map must show the name of the operator, the state, the county, and the township of the mine's location. It shall also show the boundaries of the company's mining rights, the section and quarter section lines, town lots, public roads and rail road tracks. All drill holes penetrating the coal seam or seams being mined, rivers and other bodies of water which might affect mining shall be shown on the map. All shafts or other openings to the surface or into other mines, all active workings, all abandoned places, seals, and the general areas where pillars have been extracted, the locations of pumping stations, transformer and motor-generator stations and seam out0cropping, if any shall be shown on the map. If the surface buildings, roads, and rail road's are so extensive that they can't be drawn on under the ground map, then a separate map for the surface must be made.

Should any operator of any mine not furnish mine maps as required by law, then the state mine inspector can order a survey made and the expenses incurred are to be paid by the operator. If the inspector of the state mining board deems a map to be materially inaccurate, then the inspector may order a different survey made; if no serious inaccuracies are found the state must pay for the re-survey, otherwise the operator bears the expenses incurred.

Final Maps to be Made of Abandoned Mines. A final survey shall be made of all the mines about to be permanently closed. A copy of such maps shall be furnished by the department of mines and minerals and the county recorder within 90 days after such mine closing.

Maps of Mines Sold or Transferred. Within 30 days after the title of a mine has been transferred two copies of a correct map shall be filed with the county recorder of the county where the mine is located and one copy with the state department of mines and minerals. Both the seller and the purchaser must certify on each map as to its correctness; such maps may be used in courts of law.

All Mine Openings of Abandoned Mines are to be Permanently Enclosed. Sealed or Filled. All abandoned mine shafts or openings to the surface shall be filled, sealed or kept permanently enclosed.

How a State Mine Inspector Proceeds to Inspect a Coal Mine. Before an inspector goes to a coal mine to make his first inspection, he should procure a copy of the mine map and make a study of it, the mines location, the system of mining practiced, the ventilating system, etc. Then he should go unannounced, introduce himself, show his credentials, and make an acquaintance with the mine officials. After this, perhaps one of the first things he'd do would be make a careful study of the different examiners' reports and if he finds anything about these reports which he needs to question, discuss this with the proper mine official. After this he would make an inspection of the surface buildings, the hoisting room and hoisting equipment, the recording pressure gages and take measurements of the intake and return air at these shafts. After he had completed his surface inspection, he would take a cage and go underground; for his own safety and convenience he should have either a company official or someone assigned by the management to accompany him on his underground inspection. He should carefully inspect all of the active working places, belt lines, and travel ways, stopping to converse with each workman as he makes his "rounds", getting acquainted and listening to what they have to say; most generally it is better if he talks to the workmen while by himself so as to make the conversation confidential. He should take special notice, the practices of the different workmen and observe if the mining laws are being obeyed. He should take all the necessary air readings and compare these with those of the examiners which he made note of, he should examine escapeways, make the "gas" test, take air and dust samples as he deems necessary and when finished underground return to the surface. When he has completed his inspection, he should make an inspection report; post an inspection notice on the mine bulletin board, reporting his findings and any recommendations he deems need to be made.